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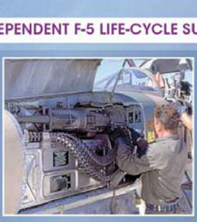

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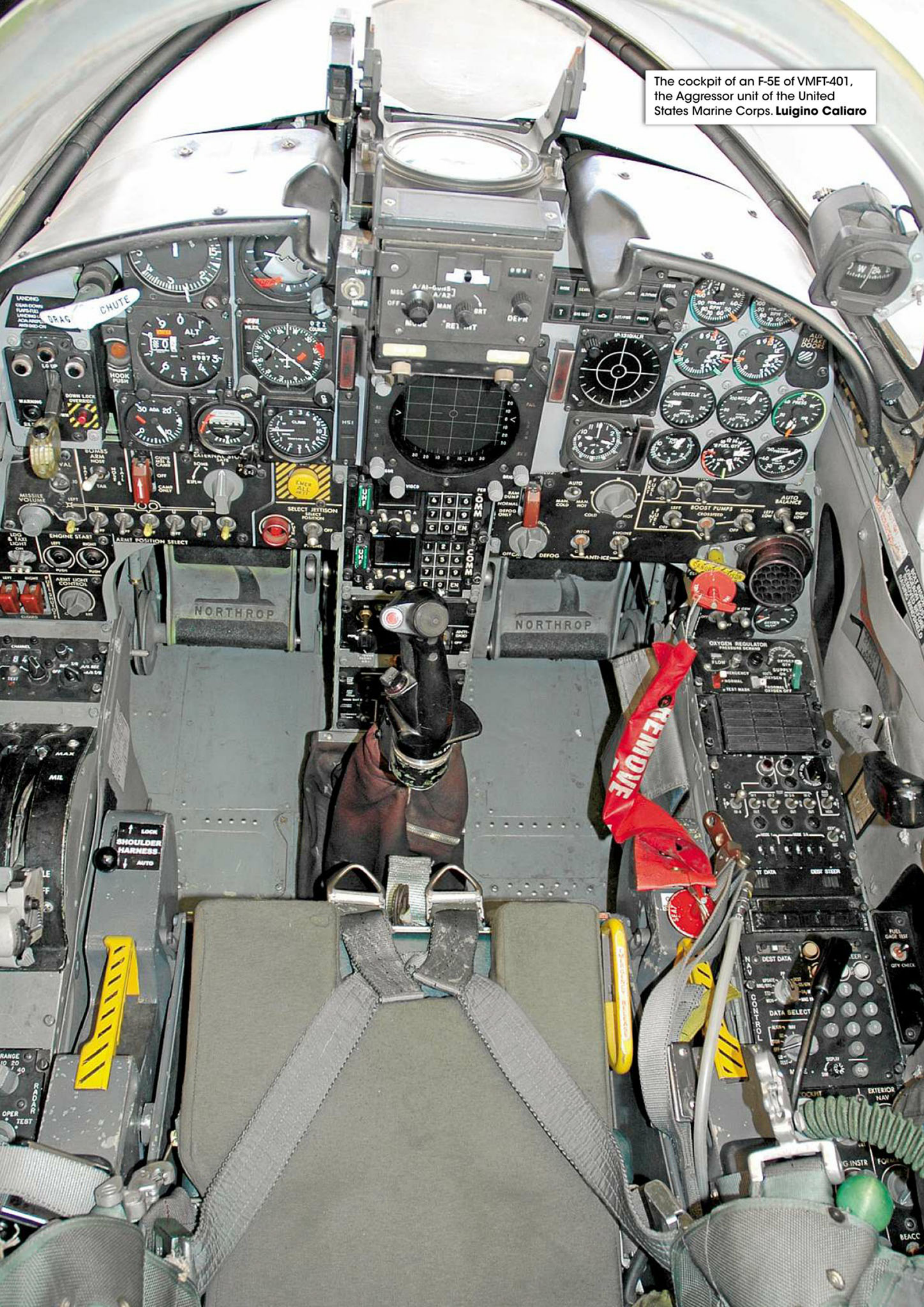

The cockpit of an F-5E of VMFT-401, the Aggressor unit of the United States Marine Corps. **Luigino Caliaro**

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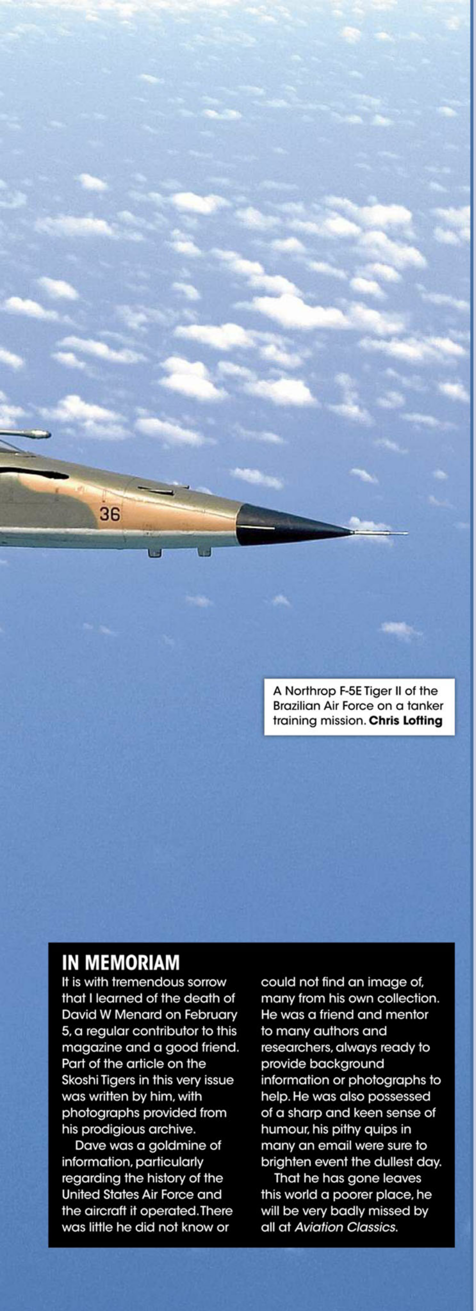

A Northrop F-5E Tiger II of the Brazilian Air Force on a tanker training mission. **Chris Lofting**

IN MEMORIAM

It is with tremendous sorrow that I learned of the death of David W Menard on February 5, a regular contributor to this magazine and a good friend. Part of the article on the Skoshi Tigers in this very issue was written by him, with photographs provided from his prodigious archive.

Dave was a goldmine of information, particularly regarding the history of the United States Air Force and the aircraft it operated. There was little he did not know or could not find an image of, many from his own collection. He was a friend and mentor to many authors and researchers, always ready to provide background information or photographs to help. He was also possessed of a sharp and keen sense of humour, his pithy quips in many an email were sure to brighten event the dullest day.

That he has gone leaves this world a poorer place, he will be very badly missed by all at *Aviation Classics*.

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Editor: Tim Callaway
editor@aviationclassics.co.uk
Publisher: Dan Savage
Contributors: Cdr Dave Baranek, Luigino Caliaro, Cdr Francesco Chierici, Juan Carlos Cicalesi, Capt John Cole, Keith Draycott, Cdr Max Dugan, Julian Humphries, Dave Jefferys, Chris Lofting, Jose Matos, David W Menard, Glenn McCormick, Jos M Ramos, Constance Redgrave, Warren Thompson, Adam Tooby

Designer: Charlotte Pearson
Reprographics: Jonathan Schofield

Group production editor: Tim Hartley

Divisional advertising manager: Sandra Fisher
sfisher@mortons.co.uk
Advertising sales executive: Lewis Broadhurst
lbroadhurst@mortons.co.uk
01507 529574

Subscription manager: Paul Deacon
Circulation manager: Steve O'Hara
Marketing manager: Charlotte Park
Production manager: Craig Lamb
Publishing director: Dan Savage
Commercial director: Nigel Hole
Managing director: Brian Hill

Editorial address:
Aviation Classics
Mortons Media Group Ltd
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Lincs LN9 6JR

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Customer services, back issues and subscriptions:
01507 529529
(24 hour answerphone)
help@classicmagazines.co.uk
www.classicmagazines.co.uk

Archive enquiries: Jane Skayman
jskayman@mortons.co.uk
01507 529423

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Swimming upstream

Welcome to the second edition of *Aviation Classics* supported by the aviation industry. Joining Saab, we would like to thank RUAG Aviation, the Swiss aerospace group that maintains, upgrades and supports the Swiss Air Force Northrop F-5s that were built under licence in the country. Thanks to them, once again I find myself at the end of producing an issue having learned a vast amount about a subject I thought I knew well. As anyone who reads this page knows, that is one of the joys of this job.

So it was with Jack Northrop and the companies he founded, the last of which went on to build the lithe, shark like fighter this issue is dedicated to. Before I told the story of the company, I wanted to tell the story of the man. Not just because his flying wings captured my imagination as a boy, but because his lifelong work to advance aerodynamics in his very individual way is why I believe the fighter existed in the first place.

Let me explain. All his life Jack Northrop wanted to go his own way, develop his ideas. This ambition manifested itself in the list of companies he founded and the aircraft he designed while working at them. It was also evinced by the fact that once he was forced from the drawing board, once he was unable to do what he felt was his calling in life, he left, usually to begin again from scratch. That he always found backers and supporters for his new ventures speaks volumes for the obvious value of his ideas and designs. His innovations always made money. Ask the Lockheed brothers, ask Donald Douglas, every aircraft that Jack designed for them sold in hitherto unheard of volumes. But every time, once the desire set in to keep making money and stop taking chances at the cutting edge of aeronautical development, Jack Northrop left.

Now, is that arrogance? A Nordic stubbornness perhaps? Or instead is it a vision so clear, so breathtakingly simple, that the man had to pursue it no matter what the cost. Jack Northrop spent his whole life going against the grain, swimming upstream, in order to build the most efficient and effective aircraft he could. He never took the easy, accepted route to solve problems he encountered, always trying the unexpected or innovative to get to where he wanted to be. To me that is courage, pure and simple.

Many people see the Northrop Grumman B-2 Spirit as a vindication of Jack's greatest dream, the pure, birdlike efficiency of the true flying wing. I see it as the second step, the first was taken by the man himself in the XB-35 and Y-B-49. Look at the designs other companies have been proposing for years, blended wings, flying wings, cargo transports and airliners that have little in the way of a fuselage. One day one of them will have the courage to build one, to take that next step in the evolution of the truly efficient aircraft. Many already have in the stealthy UAVs and UCAVs currently on the market. Not a lot of fuselage there either you might note.

So what has this to do with the F-5 I hear you ask? Well at the time Tom Jones, Welko Gasich and Lee Begin were working on the idea proposed by Edgar Schmued, every other fighter on the drawing board was bigger, more powerful and better armed with more complex systems. The F-5 was exactly the opposite, small, inexpensive and simple. It was a real risk, by people who had mostly learned their trade working with a man for whom taking risks was the way forward. This particular risk went on to become one of the best selling and longest lived jet fighters in aviation history. Through upgrades, today it boasts capabilities that are the equal of its larger brethren. I like to think the spirit of Jack Northrop lived on in his company after his retirement, and like him, the F-5, the little shark of a fighter, successfully swam upstream.

All best,
Tim

A much upgraded, CASA built F-5M two seat trainer of the Spanish Air Force shows why the slim little aircraft is such a favourite with instructors, as the rear seat pilot can see over the pupil's head. **Chris Lofting**

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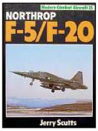

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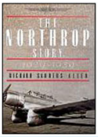

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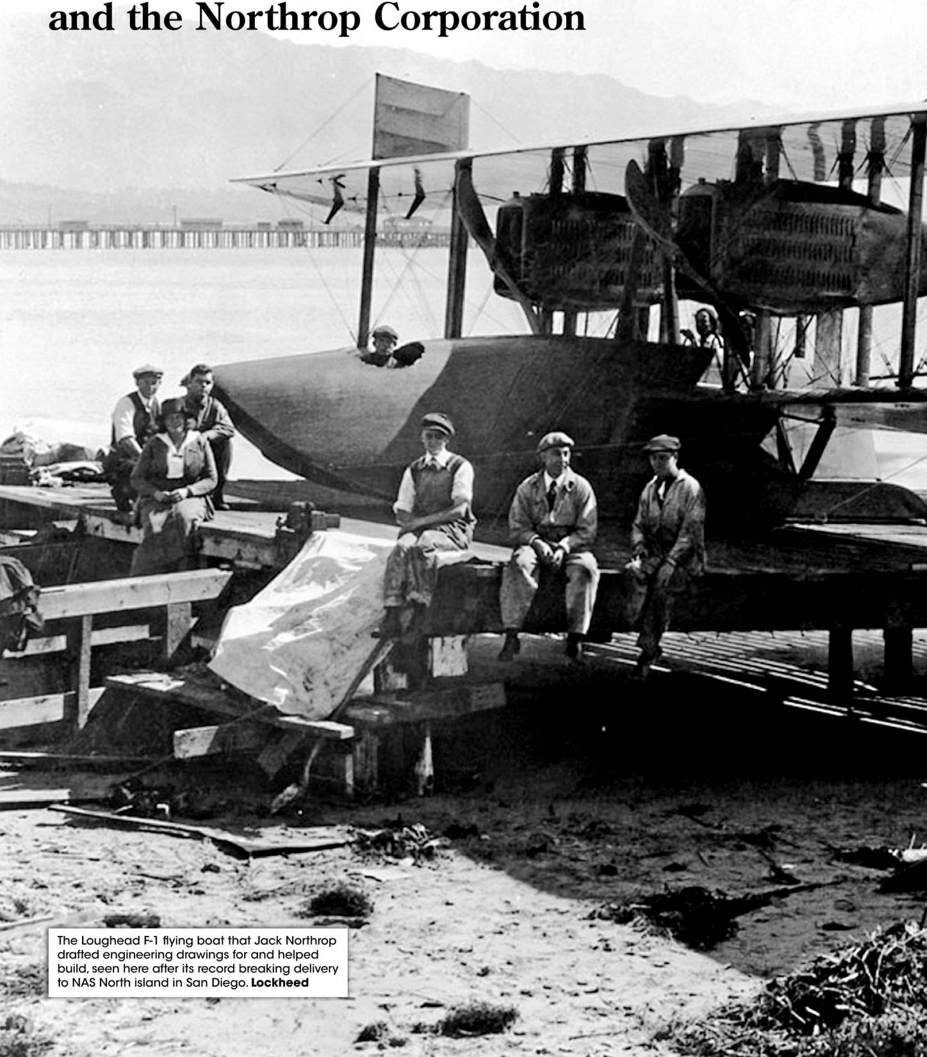
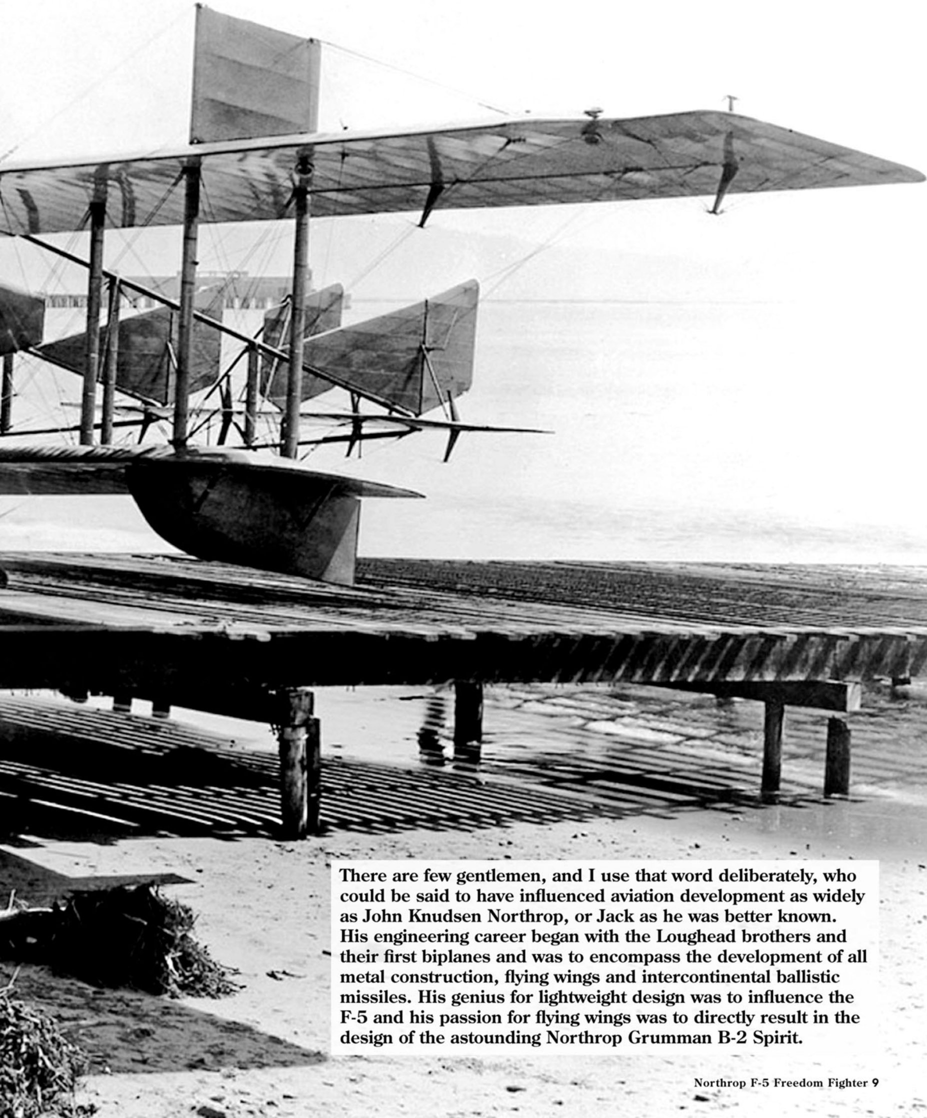
Gentleman Genius

A short history of John Knudsen Northrop and the Northrop Corporation

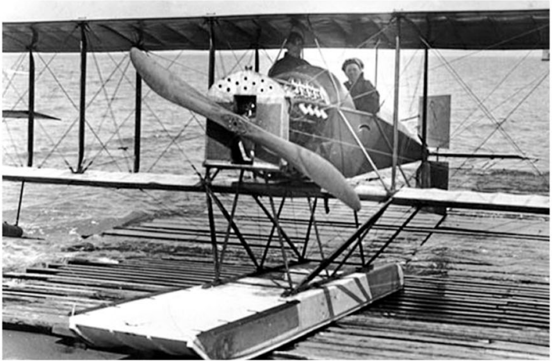


The Loughead F-1 flying boat that Jack Northrop drafted engineering drawings for and helped build, seen here after its record breaking delivery to NAS North island in San Diego. **Lockheed**



There are few gentlemen, and I use that word deliberately, who could be said to have influenced aviation development as widely as John Knudsen Northrop, or Jack as he was better known. His engineering career began with the Loughead brothers and their first biplanes and was to encompass the development of all metal construction, flying wings and intercontinental ballistic missiles. His genius for lightweight design was to influence the F-5 and his passion for flying wings was to directly result in the design of the astounding Northrop Grumman B-2 Spirit.

Jack Northrop where he was most comfortable, drawing the future of aviation. **Northrop**



The Alco Hydro-Aeroplane Company Model G in San Francisco with the Loughead brothers. **Lockheed**

EARLY LIFE

John Knudsen 'Jack' Northrop was born in Newark, New Jersey, on November 10, 1895, the only child of Charles Wheeler Northrop and Helen Knudsen Northrop. Charles was her second husband; Helen was a widow with two sons, Roy and Donald Lippincott, so the young Jack grew up with two older half brothers.

The family left Newark when Jack was very young, heading west to Chicago, then on to Lincoln, the capital of Nebraska. Even though Charles quickly found work in Lincoln's largest department store, the family were enthusiastic hikers and campers and found the flat land of the Lincoln area to offer few attractions in this regard. The beaches and mountains of California proved to be a much more attractive prospect for the intrepid family, so their small savings were invested in the move to Santa Barbara in 1904, where Charles built a two room tent house with a wooden floor and canvas cover in a canyon close to the beach, but within easy bicycle reach of town.

Charles quickly found work as a carpenter and nine-year-old Jack joined the local boy scout troop, feeding his love of outdoor pursuits; a membership he was to enjoy for many years. The family became increasingly well established in the idyllic climate of Southern California, Charles founding his own building contractor business which grew alongside the burgeoning local economy, purchasing his first car in 1912.

Jack added a love of music to his interests, becoming adept at accompanying the family on the ukulele and accordion. He attended Santa Barbara High School where he received a thorough grounding in subjects he was to find fascinating. Maths, geometry, algebra, physics, chemistry and mechanical drawing were all skills his fertile mind took to with a will, all of which were to stand him in good stead in later years.

In order to assist the family while he was in school, Jack had taken a job in an automobile repair shop at the end of State Street near Santa Barbara beach in order to pay his way through school while his father built up his business. This had an important effect on the young man, as he discovered a mechanical aptitude for repairing and improving machines. He could see how any device he encountered could be modified to make it more efficient or longer lasting and tinkering with machines became a joy that would last his whole life.

In 1911, the French pioneer pilot Didier Masson made a flight over Santa Barbara, landing on the lawn in front of the Potter Hotel downtown. Sixteen-year-old Jack was much influenced by what he witnessed, especially the mechanics and construction of the aircraft. Even at this early age he was convinced he could improve upon the design and engineering of these early aeroplanes. Time was to prove him right.

What happened next speaks volumes for the character of this decent and immensely likeable young man. His half brothers were able to attend college due to a legacy bequest from their late father, but the family fortunes at that time were still not well enough established to allow Jack to attend. On graduating from high school he made the decision to seek employment and not to ask his father for support, instead to bring an extra income to the family. This one decision may explain a great deal about his innovative approach to aircraft design in later years. Jack Northrop had watched soaring birds as a boy and drew inspiration from nature, from the evidence of his own eyes. He was unencumbered by the accepted understanding of aviation and aerodynamics; instead he was free to choose his own path as his keen instinct and precise, logical mind dictated.

King Albert of Belgium with Allan Loughead in the cockpit of the F-1 flying boat, King Albert holding a camera. **Lockheed**

FATE TAKES A HAND

When Jack graduated from high school in 1913, he spent three months at the cattle ranch of his mother's cousin, Augustus Knudsen, on the Hawaiian Island of Kauai at the invitation of the family. At the time the island was largely undeveloped, a wilderness Jack's love of the outdoors was to delight in. Later, Jack was to recall that the three months were a character building experience; immersing himself in another culture in a new land taught him much that would serve him well in later life.

On his return home, he was offered a job by an architect friend of his father, who utilised his talents as a mathematician and draughtsman. Over the next two years, he also worked for his father's construction company, gaining a solid grounding in the mechanics of design and construction, the use and strength of materials and dealing with customers and colleagues.

His abiding fascination with machines meant he still visited the automobile repair workshop he had worked in while at school, and in early 1916 fate took a hand. A small company established a workshop in the same building on State Street, run by two brothers. They were building a large, twin-engined flying boat, a machine the 20-year-old Jack found irresistible. The business was the Loughead Aircraft Manufacturing Company, moved down from San Francisco, and the brothers were Allan and Malcolm Loughead.

The Loughead brothers were two of the great American pioneers of aviation and had already built their first aircraft, the Model G seaplane, with their first business, the Alco Hydro-Aeroplane Company. This had first flown in 1913, and despite initial financial difficulties, the brothers had used the seaplane to fly passengers at the San Francisco Panama-Pacific International Exposition of 1915. Over 600 people took their first flights in the Model G over the course of five months, each paying $10, a considerable financial success for the aviation industry of the day. With the move to Santa Barbara, the Model G continued to provide income. Many people wanted to take their first flight, movie companies wanted aerial footage and the offshore islands were a popular destination for charter flights.

Allan (right) and Malcolm Loughead in the cockpit of the F-1 flying boat. **Lockheed**

They were using the income to fund the construction of their next aircraft, the huge, 10 seat, twin engined F-1 flying boat, the intention being to increase their passenger business. Like the earlier Model G, the brothers were building the new aircraft by the light of experience, tackling problems in the construction as they arose. The observant Jack Northrop suggested that his skills as a draughtsman and construction engineer could save them time and money in allowing him to make stress calculations and draw up components for fabrication. Allan and Malcolm Loughead were no fools and accepted Jack's suggestion with alacrity, hiring him immediately and setting him to work designing the wing struts for the flying boat.

Eventually, Jack would produce a complete set of engineering drawings and schematics for the F-1, working alongside construction foreman Anthony Stadlman. Given Jack's background in practical construction and engineering drawing, this hands-on experience was the best possible start to what would be a stellar career.

At this time, Jack Northrop began a habit that would last his entire career. He always kept a drawing board at home, complete with paper, pencils and slide rule, that would enable him to sketch ideas as they came to his fertile imagination. Later, when he established his own company, he maintained a drawing board in his office where many of his most innovative ideas first came to life. While working on the F-1, Jack began studying materials, structures and stresses, building up a considerable library of textbooks on engineering subjects, all of which knowledge he put to good use at Loughead.

In 1917, the United States entered the First World War, so Allan Loughhead went to Washington to seek a contract to build the F-1 for the US Navy. In this he was unsuccessful, but did get a contract to build two Curtiss ➤

The US Navy gave Loughead Aircraft a $90,000 contract to build two Curtiss-designed HS-2L scout seaplanes. This is the first in 1918. **Lockheed**

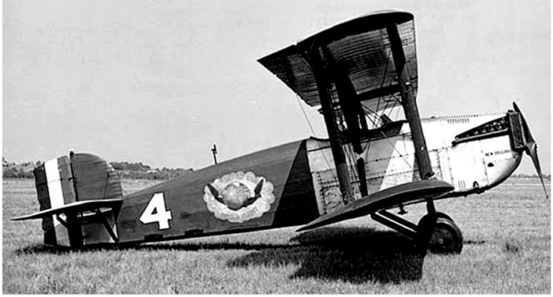
HS2L Flying Boats under licence, and a promise that the navy would evaluate the F-1 when it was completed. Meanwhile, Jack was drafted into the US Army, completing his basic training at Camp Lewis in Washington. His aviation experience meant he was transferred to the Army Signal Corps, which was responsible for military aviation at the time, before it was realised that his skills as an engineer were far better utilised in assisting the Loughead Company to build the Curtiss flying boats for the US Navy. He was returned to the company and discharged from the army when the war ended in 1918, but as usual with the young entrepreneur, he took his short time with military aviation as valuable experience which would come in useful later.

The F-1 was completed and flown to San Diego for the promised navy trials in April 1918, setting a record for the 211 mile flight from Santa Barbara as it did so. The two Curtiss HS2Ls were completed at about the same time, meaning that by 1919 the company had no further work. The F-1, which Northrop had helped convert to the F-1A landplane for a short period in an attempt to interest the army in it as a bomber or transport aircraft, was returned to its flying boat configuration and used for its original purpose, flying passengers and movie work. King Albert and Queen Elisabeth of Belgium took a flight to Santa Cruz Island in the F-1, among many notable personalities of the time.

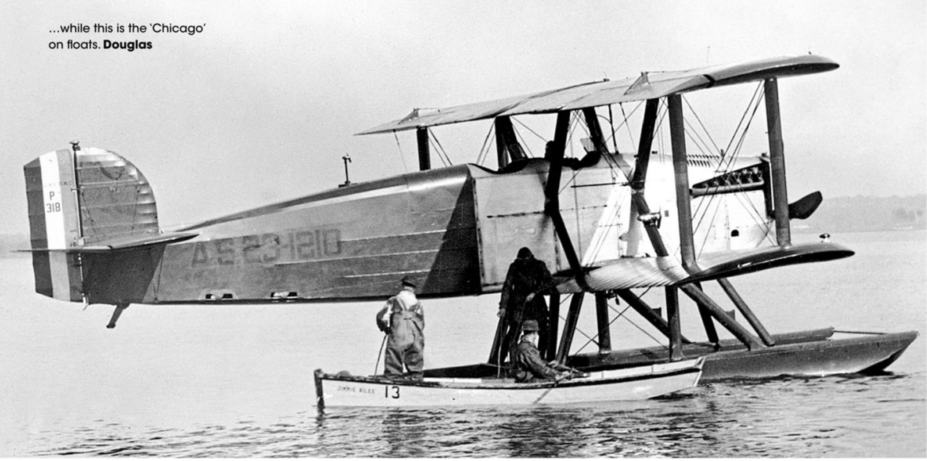
FIRST DESIGN

With a lack of both orders and construction work, Northrop began designing a new light sport aircraft at Loughead, one with a number of innovative features. Originally a two seat design, as the project developed the second seat was deleted to reduce costs. Tony Stadlman had seen a German Albatros D.Va fighter displayed in San Francisco shortly after the war's end, and described the monocoque plywood fuselage construction to Jack, who was intrigued. They worked out a system using two concrete moulds and inflatable balloons. The balloons held wet plywood sheets inside, shaping them to the contours of the mould while the glue dried and they hardened to permanently retain the shape. The top and bottom halves of the fuselage were thus single pieces, resulting in a very strong yet lightweight structure. Once removed from the moulds, the halves were simply trimmed and glued together.

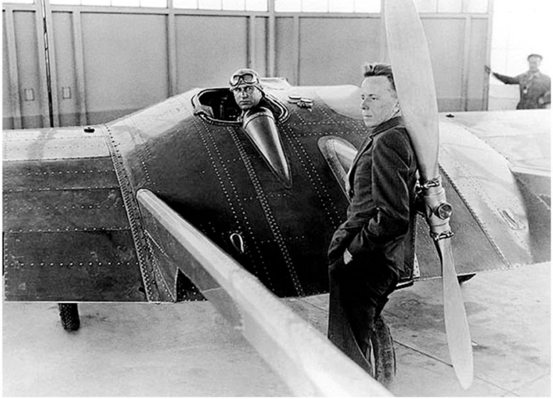
The Loughead brothers, Northrop and Stadlman received a joint patent for the monocoque process, as they had all contributed. A suitable powerplant for the new design was not available, so the ever practical Stadlman designed and built the XL-1, a two-cylinder 25hp water-cooled aero engine which proved remarkably reliable. The wings had a number of uniquely Jack Northrop features. Constructed of wood ribs and spars and covered in fabric, the structure was conventional; what they could do was not. Firstly, to enable the S-1 Sport Biplane, as it was now known, to be easily stored in a garage, the wings could be folded alongside the fuselage. The lower wings could also be rotated around their spar in flight, allowing them to act as ailerons, flaps and airbrakes, arguably the first use of flaps on an aircraft. Northrop had watched the seagulls at Santa Barbara twist their wings almost vertically to achieve slow flight for landing, and reasoned that an aircraft with a similar ability would have excellent slow flight characteristics and a short landing run. He was correct in both respects, as flight testing in late 1919 revealed. Test pilot Gilbert Budwig described the S-1 as the most flyable aircraft he had ever flown, with excellent handling throughout the



The Douglas World Cruisers (DWC) were a modified version of the Douglas DT torpedo bomber with interchangeable float and wheeled undercarriages to enable them to make a round the world flight. This is the 'New Orleans' on wheels… **Douglas**



…while this is the 'Chicago' on floats. **Douglas**



Jack Northrop leans against the propeller of his first flying wing design of 1929. Test pilot Eddie Bellande is in the cockpit. **Northrop**

The redoubtable Anthony Stadlman, designer and engineer, seen here with a flying wing model in 1929. He was to influence Jack Northrop's thinking about aircraft design to a remarkable degree. **Lockheed**

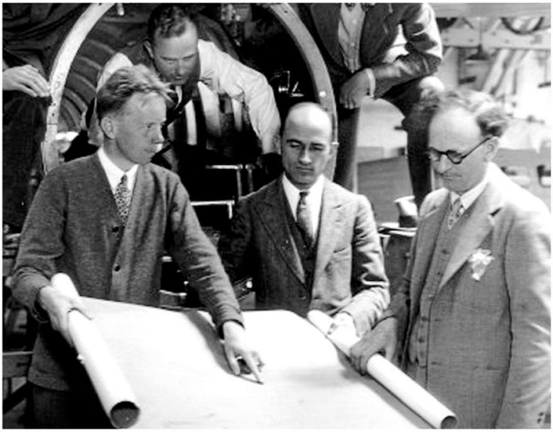
speed range, from the maximum of 75mph (121kph) to the stall at 25mph (40kph).

Hundreds of successful flights were made, including at an air show in San Francisco where thousands admired the clean lines of the S-1. Unfortunately, the light aircraft market of the time was flooded with cheap war surplus types selling for as little as $300, so no orders for the $2500 S-1 were received, forcing the Loughead Aircraft Manufacturing Company into liquidation in 1920.

Unemployment for Jack was particularly hard at this time as he had married his high school sweetheart, Inez Harmer, in 1918 and they were starting a family. They had waited until Jack had been discharged from the army and was able to support them before marrying, so the closure of the company was a blow to their hopes.

For the next three years, Jack worked alongside his father Charles in his construction company, drafting and designing new homes. By 1923, even the construction business was experiencing financial difficulties, so both father and son were forced to find new work. Allan Loughead knew Donald Douglas and put in a good word for Jack, who had applied for a job at the Santa Monica factory of the Douglas Aircraft Corporation. The company had just been awarded a contract to build four special biplanes for the US Army for a planned flight around the world. Known as the Douglas World Cruisers (DWC), the aircraft were a modified version of the Douglas DT torpedo bomber with interchangeable float and wheeled undercarriages to enable them to make a round the world flight in stages, stopping at refuelling points.

Considering that in 1923 the Atlantic had only been flown once by a fixed wing aircraft, this was an extraordinary undertaking. Jack was put to work in the assembly shop, constructing wing ribs, before being promoted to engineer and asked to design the fairing for the steel tube fuselage. Jack had never worked with this kind of structure to that point, so was at a loss as to how to begin. Fortunately, the following day he was swapped on to designing and building the aluminium fuel tanks, a task he was familiar with. The four aircraft, named Boston, Chicago, New Orleans and Seattle, set off from Seattle on April 6, 1924. Two aircraft were lost on the voyage, Boston being replaced by the Boston II, with the three aircraft returning to Seattle on September 28, an astounding achievement for the time.



The Lockheed designers and managers working on a Vega in 1929. Jack Northrop (left), Jerry Vultee (inside the Vega), Bill Henry and Allan Loughead. **Lockheed**

LOCKHEED REBORN

With the end of the DWC project in 1924, the engineering staff at Douglas were reduced to just two, Art Mankey and Jack Northrop. Donald Douglas had recognised Jack's extraordinary talents, putting him to work on a variety of design projects for the military aircraft Douglas was producing at the time, including the 0-5, an army observation version of the DWC. While at Douglas, Jack worked with some of the great designers and innovators of aviation history, including John Leland 'Lee' Atwood, who was the head of stress department, and James Howard 'Dutch' Kindelberger, both of whom were later CEOs of North American Aviation and both of whom had a hand in the design of the DC-1, DC-2 and the ubiquitous DC-3.

The engineering team had grown to nearly 50 engineers by 1926, and Jack found himself performing calculations and designing parts rather than whole aircraft. At home on his personal drawing board, he had been working on the design for a high wing monoplane with a monocoque fuselage inspired by the earlier S-1 sport aircraft. He was still meeting regularly with his friend Allan Loughead, discussing new ➤

ideas and aviation projects whenever they could. Jack showed him the drawings for the new aircraft which galvanised Loughead into raising capital and forming a new company. Kenneth Jay, an accountant and friend of Loughead, introduced him to Fred S Keeler, a very successful local brick and ceramics manufacturer, who agreed to finance the project.

The Lockheed Aircraft Corporation, so named because Loughead was tired of the mispronunciation of his name, was founded between Fred Keeler as president, Allan Loughead as vice-president, Jack Northrop as chief engineer and Kenneth Jay as general manager in December 1926. The redoubtable Anthony Stadlman was brought back into the new company as shop superintendent, completing the old team from the S-1 project.

Interestingly, Stadlman had become increasingly convinced of the possibilities inherent in flying wing designs, constructing several models of tailed flying wings which he showed to Jack Northrop. Stadlman's ideas were to begin Jack's lifelong interest in flying wings and shaped much of his thinking for the rest of his career.

Jack left the Douglas Aircraft Company and moved offices to the new company's first facility, a converted garage in Hollywood. Early in 1927 work began on the sleek monoplane, using Jack's original drawings from home. Less than six months later, on July 4, 1927, in a hayfield in Inglewood, test pilot Eddie Bellande took the first Lockheed Vega on its maiden flight.

While work on the Vega was progressing, during this period Jack was also doing some design consultation for Claude Ryan and Frank Mahoney at Ryan Airlines in San Diego with Allan Loughead's consent. Jack was working on helping lighten and stretch the wing of their Ryan M2 mailplane design, increasing the span by 10ft and improving the aerodynamic efficiency of the new wing. Jack's design changes included lighter ribs and a plywood skin that covered the leading edge of the wing as far back as the spar. This wing was a one-off, as it was fitted to the sole example of the Ryan NYP, the famous Spirit of St Louis that Charles Lindbergh flew on the first nonstop flight between New York and Paris on May 20-21, 1927.

The Northrop Beta 3 of 1931, a two seat racing and sport aircraft. **Northrop**

A Northrop Alpha 2 was a six passenger transport with all metal stressed skin construction. It first flew in 1930. **Northrop**

The Lockheed Vega was also built with a metal monocoque fuselage by the Detroit Aircraft Corporation, one of which was ordered by the USAAC as the Y1C-12. **USAF**

VEGA TRIUMPHS

This flight caused a resurgent interest in aviation world wide, a situation the new Lockheed Vega was ideally placed to take advantage of. The high wing monoplane could accommodate four passengers in the cabin as well as the pilot in an enclosed cockpit. It was powered by a 225hp Wright Whirlwind nine-cylinder radial engine which gave the aircraft a cruising speed of 120mph (193kph), a performance which allowed the aircraft to set no fewer than 34 endurance and speed records.

The first Vega was purchased by William Randolph Hearst at the request of his air enthusiast daughter-in-law, Blanche Wilbur King, and named Golden Eagle. It was entered in the Dole Race of August 1927 from Oakland to Honolulu in Hawaii, but sadly disappeared en route. Before this tragedy occurred, Captain George Hubert Wilkins had seen the aircraft on a test flight and was much impressed. He ordered the third Vega off the production line, the second being a company demonstrator, and equipped it for Arctic exploration. In April 1928, Wilkins and pilot Carl Ben Eielson completed a flight from Point Barrow, Alaska, to the island of Spitzbergen. The performance of the Vega was further highlighted at the 1928 National Air Races in Cleveland, Ohio, when the type won every speed event.

Every famous record-breaking, long distance and racing pilot of the time wanted the aircraft, including Wiley Post, Amelia Earhart, Roscoe Turner and Jimmy Doolittle. In March 1928 the company had to move to a new facility in Burbank in order to meet the demand for Vegas. By the end of the year 68 of the type had been built to an order book that exceeded one million dollars. Jack's sleek design was an incredible success, establishing him firmly at the forefront of aircraft designers of the day.

The four-seat cabin of the original Vega was considered too small by the airlines, who pressed for an expanded version with at least

Named Polar Star, the sole Gamma 2B was used on the first flights over the Antarctic in November 1935 by Lincoln Ellsworth's expeditions to the continent. **Northrop**

six passenger seats. On top of this, a request for a low wing seaplane version, to be called the Lockheed Explorer, and an open cockpit mailplane version of the aircraft called the Lockheed Air Express meant that the design and engineering work was increasing at the new company. Gerard 'Jerry' Freebairn Vultee, an engineer Jack knew from his days at Douglas, was hired in early 1928 to assist in this work. However, despite the new models of the Vega being produced, Jack saw that there was no interest in developing entirely new designs and construction techniques while the company had such a success on its hands, and he was brimming with new ideas.

Both he and Kenneth Jay left Lockheed in the middle of 1928 in order to found their own company to develop all-metal aircraft and other concepts. Having been the first customer for the Vega, Blanche Hearst was a member of the board of the Avion Corporation, as the new company was named, bringing vital investment from her father-in-law, William Randolph Hearst. Free to follow his own design interests at last, the founding of the Avion Corporation at Burbank allowed Jack Northrop to produce some ground-breaking aircraft over the next few years.

Texaco bought the first Gamma 2A with Frank Hawks using it for record breaking flights across the US in 1933. **Northrop**

THE FIRST WING

In 1929, what can be considered Jack's first flying wing design, albeit with a boom mounted tail, took shape at the Avion Corporation. It was far removed from the designs Jack had been working on in many ways, being of completely metal skinned construction, having a pusher propeller and a twin boom fuselage layout. While at Lockheed, Jack had been considering the advantages of monocoque metal skin, where the skin actually took much of the loads imposed on an airframe, and had completed a great deal of research into the use of the new lightweight aluminium alloys then under development. This research was to be put to good use in all the aircraft Jack produced from then on, the success of the new designs ensuring his concepts were widely accepted throughout the aviation industry.

Several layouts for the flying wing were investigated, with two different Menasco engines being considered for both pusher and tractor propeller configurations, before a 90hp Menasco Cirrus Mk.III was chosen driving a pusher propeller via a 7ft long shaft. The inverted four-cylinder engine was mounted in a tunnel in the wing to allow cooling air to pass over it. The 30ft 6in (9.3m) span wing was deep enough to allow a single seat cockpit to be fitted on either side of the propeller shaft, the starboard cockpit being covered over for the flight tests. Although it was intended to have a retractable undercarriage, designed by Jack in co-operation with Los Angeles based Menasco, it was decided to fit a simpler and lighter fixed nosewheel undercarriage, itself a rarity among aircraft of the time.

The prototype was given the registration X-216H and taken to Muroc Dry Lake in the Mojave Desert, now the site of Edwards Air Force base and home to many unusual aircraft since then. Test pilot Eddie Bellande, the man who first flew the Lockheed Vega, carried out a test flying programme with the aircraft up until September 1930, finding the unique machine to have normal flying characteristics, demonstrating an excellent climb rate and high speed for just 90hp. Although it was fitted ➤

The Gamma 2E purchased by the British Air Ministry as K5053 and evaluated at the Aircraft and Armament Experimental Establishment at Martlesham Heath. **Northrop**

with a tailplane, the results of the test programme convinced Jack he was on the right track, the data obtained would help shape the first true flying wings he would produce 10 years later. Although the fate of X-216H is unknown, this remarkable machine was incredibly far ahead of its time and can be considered one of the milestones of aviation history.

While the flying wing was being designed and built, the ever busy Jack Northrop was also at work on other, more conventional designs, the Northrop Alpha and Beta. These were called Northrop aircraft because during 1930, the United Aircraft and Transport Corporation (UAT) had purchased the Avion Corporation, changing the name to the Northrop Aviation Corporation.

William Edward Boeing had visited the company at Burbank and met with Jack and Kenneth Jay in early 1930 and was impressed by what he learned, seeing the potential of Jack's far reaching ideas. At the time, the Boeing Airplane Company was part of UAT, which also included aircraft manufacturers Chance Vought, Sikorsky and Stearman, engine manufacturer Pratt and Whitney, propeller manufacturers Hamilton Aero and Standard Steel and airline United Air Lines. This giant corporation had been founded to unite the US aviation industry and help it survive after the stock market crash of October 1929 which led to the beginnings of the great depression.

ALPHA AND BETA

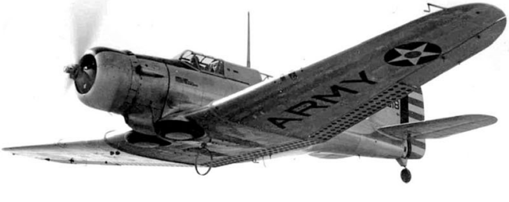
Under the new name, the company produced the Alpha, a seven seat transport, and the Beta, a single or two seat racing aircraft. The Northrop Alpha was deceptively conventional in appearance, but included a number of Jack's innovative features. Firstly it was an all-metal design with a monocoque fuselage containing a six seater cabin and single seat open cockpit. The wing was an equally innovative multicellular structure, where the skin was an integral part of the load bearing elements of the design, making it extremely strong but very lightweight. Making a low wing join to a circular fuselage was found to cause irregularities in the airflow, especially at low speed near the stall, and these effects were investigated by Jack and his team at the Guggenheim Aeronautical Laboratory at the California Institute of Technology. Wing fillets were devised that cured the problem, smoothing the turbulent airflow at the junction of wing and fuselage.

Since the problem of airframe icing was now being encountered by airlines operating commercial routes in all weathers, rubber de-icer boots were conceived and fitted to the leading edges of the wings and tailplane. In use, these would inflate slightly to cause any ice accretion on the flying surfaces of the aircraft to crack and break off.

Fast and a pleasure to fly, the Alpha first flew in 1930, with a total of 17 being built. Fourteen Alphas were used by Transcontinental and Western Air, later TWA, entering service on April 20, 1931. Powered by a 420hp Pratt and Whitney R-1340 Wasp radial engine, the Alpha was capable of 177mph (285kph). The remaining three were purchased by the US Army Air Corps as the YC-19 and Y1C-19 VIP transports with four seater cabins. During their career with TWA, several Alphas were converted to carry various combinations of passengers and cargo and had fairings fitted to the undercarriage to reduce drag, this work being undertaken by another company in UAT, Stearman of Wichita, Kansas.

With the Alpha in production, Jack developed a two seat sport and racing design called the Northrop Beta 3, powered by a 165hp Menasco C-6 Buccaneer six-cylinder inline engine which gave the streamlined aircraft a maximum speed of 175mph (281kmh). The Beta was registered NX963Y and first flown on March 3, 1931, by Edmund T Allen, a UAT test pilot. Allen then used the Beta to make a flight from Los Angeles to Detroit, via Salt Lake City, in only 15 hours and 43 minutes, causing a minor sensation at the Detroit Air Show in 1931.

Unfortunately, the aircraft was destroyed during a Department of Commerce certification flight on August 12, 1931, test pilot Lester Holoubek bailing out of the Beta when he encountered control difficulties.

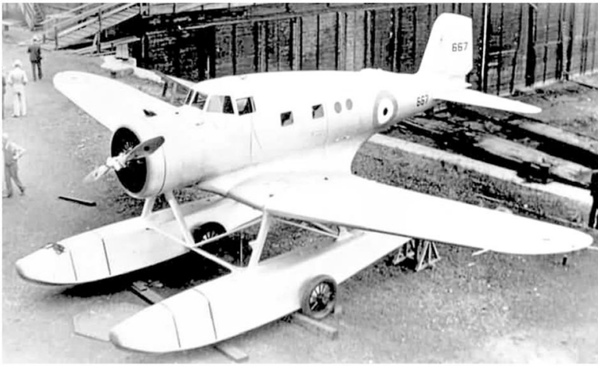


A-17As had an upgraded 825hp R-1535 Twin Wasp engine and a new fully retractable undercarriage. 129 were built for the USAAC. **Northrop**

A second Beta was built with a single cockpit and a 300hp Pratt and Whitney Wasp Junior radial engine, the modifications designed by the chief engineer at Northrop, Donovan 'Don' Berlin. Known as the Beta 3D, this aircraft had a maximum speed of 212mph (341kmh) and was registered as X12214.

With flight testing under way, UAT announced that it intended to merge the Northrop Aircraft Company with Stearman Aircraft, combining the two companies at Wichita in Kansas in early 1932. Jack had no wish to move back to the mid-West, and so left the company along with Don Berlin and Kenneth Jay.

The Beta 3D, along with all the machinery at Burbank, was moved to Wichita, where testing continued, the aircraft receiving certification approval on February 2, 1932. After two private owners and a number of modifications, Stearman purchased the Beta back, to use it as a test bed for various types of flap design. Sadly, the last Beta was destroyed in an accident on May 4, 1934.



The Royal Canadian Air Force used the Delta for photographic survey and later, on floats, as a coastal patrol aircraft. One was built as a pattern by Northrop and a further 19 built under licence by Canadian Vickers. **Northrop**

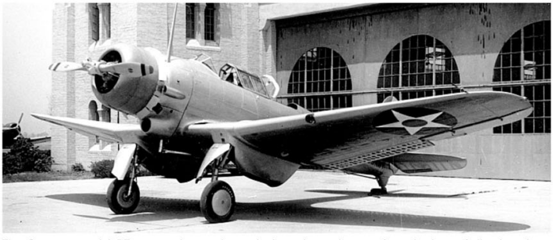
FIRST COMPANY

At the end of 1931, Jack Northrop suddenly found himself without a company, or indeed a job, but given his track record and innovative success with the Vega and Alpha, this was not to last long, despite being at the height of the Great Depression. Jack and his loyal friend Kenneth Jay went to see Donald Douglas, Jack's former employer at the Douglas Aircraft Corporation. Douglas agreed to fund the formation of the second Northrop Corporation with Douglas holding 51% of the stock, essentially making the new company a subsidiary. Jack, Kenneth Jay, chief engineer Don Berlin and draughtsman Arthur Mankey set up shop at the former White Truck and Moreland Aircraft Company factory at Inglewood on January 1, 1932, with the aim of developing innovative and experimental aircraft. Jack had already been working on a new design, the Northrop Gamma, at the former company, so very quickly the first aircraft of the new corporation was under construction, the first aircraft rolling out of the factory in 1933. Little did Jack know that this first aircraft was to be the start of a major success story for the new company.

The Northrop Gamma was a development of the Alpha design, a low wing cabin monoplane with an enclosed cockpit and tailwheel undercarriage. The high-speed aircraft was intended as a mailplane, and while TWA did operate three Gamma 2D aircraft in this role, the Gamma and its many variants were to find fame as record-breaking and military aircraft with a bewildering variety of designations and engines.

The only Gamma 1E was powered by a Pratt and Whitney Hornet and supplied to AB Aerotransport of Stockholm, Sweden, for use as a mailplane. Oil company Texaco bought the first Gamma 2A, Frank Hawks using the aircraft to establish a record from Los Angeles to New York in 13 hours 26 minutes and 15 seconds on June 2, 1933, powered by a 785hp Wright GR-1510 Whirlwind. Howard Hughes broke this record by four hours and five seconds in a modified Gamma 2G in 1935.

The only Gamma 2B was used on the first flights over the Antarctic in November 1935, during one of Lincoln Ellsworth's expeditions to the Continent. Named Polar Star, the aircraft now resides in the Smithsonian National Air and Space Museum in Washington DC. The Gamma 2C had the cockpit moved forward from its aft position to a more conventional location over the wing and was used by the US Army Air Corps (USAAC) for evaluation in 1933 as an attack bomber. It was further modified by Northrop at the army's request then returned to Wright Field and purchased by the Corps as the YA-13, later to be re-engined with a 950hp Pratt and Whitney R-1830 Twin Wasp and redesignated as the XA-16. One of the ex-TWA aircraft was modified into the supercharged high altitude Gamma 2D, used by the USAAC as the UC-100 Experimental Overweather Laboratory.



The Gamma and A-17 concept was also redesigned as a two seat carrier based dive bomber variant called the Northrop BT. This one is seen outside the factory at El Segundo. **Northrop**

A second ex-TWA aircraft was used by the Spanish Republican Air Force for coastal patrol during the Spanish Civil War, along with the sole example of the Gamma 5B produced and smuggled to Spain via South America. The Gamma 2E was another attack bomber variant, able to carry a 1100lb (500kg) bomb load.

Thirty-two complete aircraft and 25 kits in three different versions were supplied to the Republic of China Air Force which used them against the invading Japanese forces between 1934 and 1938. Two were also supplied to the Imperial Japanese Navy Air Service for evaluation in 1933 as the Northrop BXN, followed later in 1936 by the Gamma 5A and D, known as the BXN1 and 2 in Japan. The BXN2 was influential in the design of the Nakajima Type 97 carrier based attack bomber, later given the reporting name Kate.

One other Gamma 2E was purchased by the British Air Ministry as K5053 and evaluated at the Aircraft and Armament Experimental Establishment at Martlesham Heath. The Gamma 2F we will come back to in a moment, as it represents almost a separate story. The Gamma 2G and H were racing variants for Jacqueline Cochran and Russell Thaw, the sole Gamma 2J was an entry into the competition for a new basic and advanced trainer for the USAAC, which was won by the North American NA-26, and the final Gamma, the 2L, was a single specially built example for the Bristol Aeroplane Company in Britain as a testbed for the Bristol Hercules sleeve valve radial engine. ➤

MILITARY SUCCESS

To return to the Gamma 2F, the first one was powered by a 750hp Pratt and Whitney R-1535 Twin Wasp Junior 14-cylinder radial engine driving a three bladed propeller. The more streamlined fuselage featured a narrower and longer cockpit to accommodate a repositioned crew of two – the pilot and radio operator/gunner. The tailplane was redesigned and a semi retractable undercarriage fitted before it was delivered to the USAAC on October 6, 1934, for trials. The first aircraft was returned to Northrop for modifications in early 1935, including replacing the undercarriage with a fixed, faired in version, reshaping the cowling, fuselage and tailplane as well as the canopy.

When the rebuilt aircraft was returned to the USAAC on July 27, 1935, it was accepted as the first of what was to be 110 Northrop A-17 attack bombers which entered service in February 1936. These were followed by 129 A-17As, with an upgraded 825hp R-1535 engine and a new fully retractable undercarriage, and three A-17AS three seat staff transport aircraft. The type was also supplied in numbers to Argentina, Peru, Sweden, The Netherlands, Iraq, Norway, Great Britain, South Africa and Canada. Sweden built 94 A-17As as the B 5B and C between 1938 and 1941. Britain, South Africa and Canada all received aircraft intended for France, using the type as a trainer and target tug. In South America the type was to have a long service career, Argentina not retiring its examples until 1954 and Peru 1958.

One other development from the Gamma and A-17 design was produced, a two-seat carrier based dive bomber variant called the Northrop BT. The great Ed Heinemann, later to become chief engineer at Douglas, was given the task of project design engineer under Jack to produce this aircraft in 1935, having already led the design team on the fighter variants of the Delta design which will be discussed shortly.

The modification to this aircraft included an undercarriage that retracted backwards into fairings under the wings and perforated split flaps that acted as dive brakes. Powered by a 750hp Pratt and Whitney R-1535 Twin Wasp Junior, the XBT-1 first flew on August 19, 1935, and 54 of the BT-1 were ordered by the US Navy in 1936, powered by the more powerful 825hp version of the R-1535 engine. An improved version of the aircraft, the XBT-2, with leading edge slots, a new canopy and modified fully retractable undercarriage, first flew on April 25, 1938, and 144 were ordered for the US Marine Corps and US Navy. This great success was to prove to be a double edged sword for Jack Northrop.

After the absorption of Northrop by Douglas, the BT-2 became known as the Douglas SBD, the world famous Dauntless dive bomber of the Second World War. **Douglas**

DELTA BLUES

Before progressing, mention must be made of another Jack Northrop design, the Delta. This was a passenger transport development alongside the Gamma, with the same wings but a much wider fuselage accommodating eight passengers in a cabin behind the pilot's cockpit. The first Delta flew in May 1933 and was certificated in August and was intended as an airliner and executive aircraft. However, in October 1934, new regulations in the US meant that single engined aircraft could no longer be used to carry passengers at night or over rough terrain, so only three were built for airlines, one for TWA, one for Pan Am and one for AB Aerotransport in Sweden, all of which were ordered before the new rules took effect.

One was built for the US Coast Guard as the Northrop RT-1, which was used as a staff transport and the private aircraft of the Secretary of the Treasury, and seven more went to private owners, three of which ended up in Spain, one with the Rebublicans and two captured examples with the Nationalists, where they were used as transport and patrol aircraft. In 1935, the Royal Canadian Air Force selected the Delta as the new photographic survey platform; one was built as a pattern by Northrop and a further 19 built under licence by Canadian Vickers. These were to remain in service until 1941, being used for coastal patrol as well as their original purpose.

A very much scaled down version of the Delta design was proposed by Northrop as a reply to the US Navy's need for a new carrier based fighter. As with the BT, Ed Heinemann was given the task of project engineer on what became known as the XFT-1, ordered by the navy on May 8, 1933. Test pilot Vance Breese first flew the aircraft on February 16, 1934, but the type was found to have handling difficulties including spin recovery problems after trials with the navy. After many modifications and a new, larger engine, the fighter was redesignated XFT-2 and returned to the navy for further trials in April 1936. Still unsatisfactory, the aircraft was flown back to California, but crashed en route on July 21, 1936, and the contract was abandoned.

One further attempt was made to produce a fighter from the Delta and Gamma designs. In 1935, the USAAC was looking for a replacement for the Boeing P-26 Peashooter. Ed Heinemann again led a team to develop a retractable undercarriage version of the XFT-1 and –2 designs. Known as the Gamma 3A or XP-948, the aircraft first flew in July 1935, and both test pilot and USAAC evaluators quickly found the type unstable. While attempting to solve the stability problems, on July 30, 1935, First Lieutenant Frank Scare took off from Mines Field on a test flight in the prototype and disappeared; no trace of the pilot or aircraft was ever found. Again, the loss of the prototype removed Northrop from the competition.

With Stinson's Nashville plant working flat out and Vultee's Downey plant busy producing the BT-13 trainer, Northrop was given a licence to build 400 Vultee Vengeance Mk.I and Mk.IA dive bombers for a British order. **Northrop**

The big P-61 was heavily armed and fast and powerful for a big aircraft. 706 were built and served in every theatre of the Second World War. **USAF**

THE END AND THE BEGINNING

As mentioned earlier, success was a double edged sword for Jack Northrop. Firstly, it prevented him from further exploring the future of aircraft design; and secondly, the huge order books for his aircraft meant he was pressured by Douglas to focus on the existing and successful work at hand. The company had already had to relocate from the small factory in Inglewood to much larger premises, the former Pickwick Motor Coach Factory in El Segundo. This bordered the south side of Mines Field, now Los Angeles International Airport.

Given the vast scale of military orders, in 1937 Douglas took over its subsidiary as the El Segundo Division of the Douglas Aircraft Company. The aircraft types still in production were redesignated with Douglas model numbers; the Northrop A-17 becoming the Douglas Model 8, the A-17A the 8A and so on. A number of the late Model 8A-5Ns intended for Norway were used by the USAAF as the Douglas A-33. The BT-2 dive bomber, of which 144 were on order, became the Douglas SBD-1, with the last 87 being completed as SBD-2s with greater fuel capacity. The SBD became famous in the Second World War as the Douglas Dauntless. Despite the ongoing work at the now highly successful factory, and the offer of the post of chief engineer of the El Segundo Division, Jack decided in 1938 that he would leave the company as it was not offering him the design opportunities he most wanted.

It is worth recording at this point a note about Jack Northrop the man, rather than the aircraft designer. It is clear from the story thus far that he inspired tremendous trust and loyalty in his colleagues; indeed, at this point a number of them were simply waiting to see what he would do next so they could rejoin his company, whatever that turned out to be.

Jack Northrop was a quiet, shy man, modest to a fault, and as many people at the various Northrop companies all agreed, a fantastic man to work for. He would give great consideration to anyone who showed initiative and insight, but had the same degree of respect for everyone at his factories, concerning himself directly with the wellbeing of his workforce.

He was also very much a family man, reading his children a wide variety of stories at night and taking the family on hiking and camping holidays high into the lakes and mountains of California. On these he became an adept and enthusiastic fisherman, and even learned to water ski.

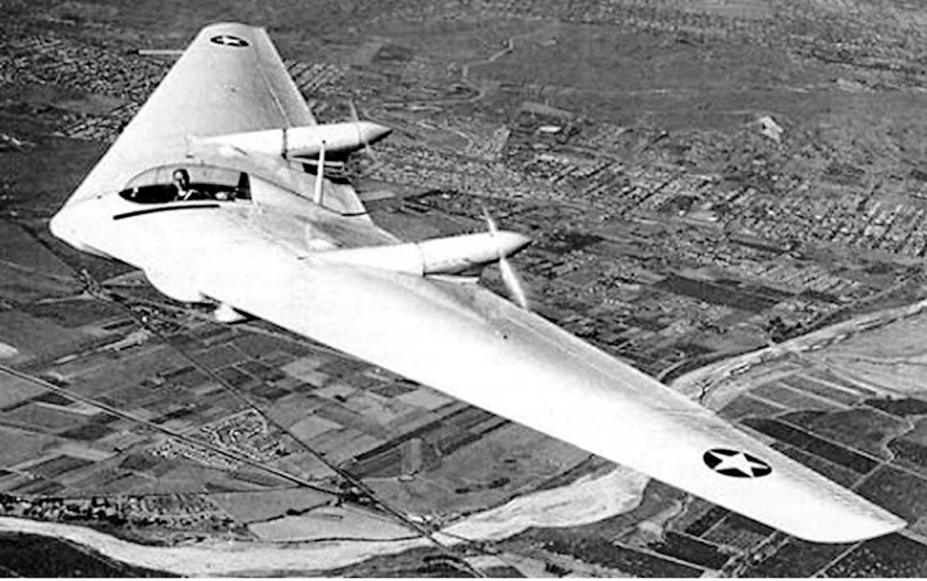
If he had a fault, it was that he sometimes mistook disagreement for disloyalty, but he was never vain nor convinced he had all the answers. He disliked vulgarity, preferring a studied approach to the problems and frustrations that beset anyone reaching for a new concept or developing new ideas. He would not fall back on old methods when a solution eluded him, preferring the radical to the conservative approach in engineering. This did lead to a number of failures it is true, but he was always honest about them and continually striving to do better, viewing every day at work as an adventure.

As a chief engineer, his was a hands-on approach, heading the preliminary design team for every new aircraft produced, calculating the dimensions and specifications of each before they ever left his office. Unlike other designers of the day, he was not aggressive or curt, but deliberate and analytical. He was the exception to the rule regarding genius, a gentle gentleman. His humanity and abilities endeared him to colleagues and competitors alike. It is a testament to his character that when the bankers behind his new venture visited Lockheed and Douglas in order to ensure no obstacles would be put in the way of the new company, both welcomed the news that he was returning to design and wished him well.

Perhaps the best summing up of the aeronautical legacy of Jack Northrop is from Donald Douglas, who much later was to say: “Every aircraft flying today has a little Jack Northrop in it.”

NORTHROP AT LAST

To return to 1938, given the fact that he had sold his shares back to Douglas, Jack now had time and finance to consider his position carefully. That he wanted to form a new aircraft manufacturing company was not in question; how to do it and how to finance it was, in order to maintain his independence as an engineer. Two pilots he knew well, test pilot Eddie Bellande and a man who had given Jack a few flying lessons in the 1920s, Moye Stephens, convinced Jack to seek a business partner with investment banking relationships. Bellande knew La Motte Cohu, a director of TWA, who had met Jack when taking delivery of a Northrop Gamma and a man well founded in modern business and administration. Jack and Cohu approached ➤



The one third scale version of the planned flying wing bomber, the N-9M-1 in flight. **Northrop**

the investment and securities firm, Banks Huntley and Company of Los Angeles, as Bellande knew the vice-president, Theodore 'Ted' Coleman. They headed an underwriting syndicate, selling $1.5 million worth of stock, including 50,000 shares, to the husband of air race pilot and Northrop Gamma owner Jacqueline Cochran, financier Floyd Odlum of the Atlas Corporation. A site in Hawthorne in Los Angeles county was located, and 300 acres of vacant land purchased on which to build a new factory.

In September 1939, just after the German invasion of Poland, Northrop Aircraft Incorporated, as we know it today, was founded, with La Motte Cohu as chairman and general manager and Jack Northrop as president and chief engineer. Four of the supporting investment companies also had seats on the board, but Jack Northrop finally had a company he could control and direct. Ted Coleman was so sure of Jack and the new company that he left Banks Huntley, becoming secretary then vice-president of sales, eventually being promoted to the board of directors.

Now the factory was under construction, the new company had to have something to build in it. Since the offices were under construction too, the disused Hawthorne Hotel was taken over as office and design shop. This building became famous as the 'Yellow Peril' due to its colour and the fact the building was infested with Black Widow spiders.

In February 1940, a purchasing commission from Norway visited the company, interested in a new floatplane for the Royal Norwegian Navy Air Service. Northrop responded with the N-3PB, a low wing, three-seat, single-engined design derived from the earlier A-17A aircraft. The commission ordered 24 of the aircraft straight off the drawing board, with the first N-3PB flying on December 22, 1940, in the hands of Vance Breese, Northrop's chief test pilot. Powered by a 1200hp Wright GR-1820 Cyclone nine-cylinder radial, the new design could reach a maximum speed of 257mph (414kph) and was considered an excellent aircraft in terms of handling.

Since Norway had been invaded by Germany by then, the first six aircraft were flown to a Norwegian training base established at Royal Canadian Air Force (RCAF) Station Patricia Bay on Vancouver Island. The remaining 18 N-3PBs were delivered to 330 (Norwegian) Squadron of the Royal Air Force, based at Reykjavik in Iceland, where they were used as patrol and convoy escort aircraft until March 1943.

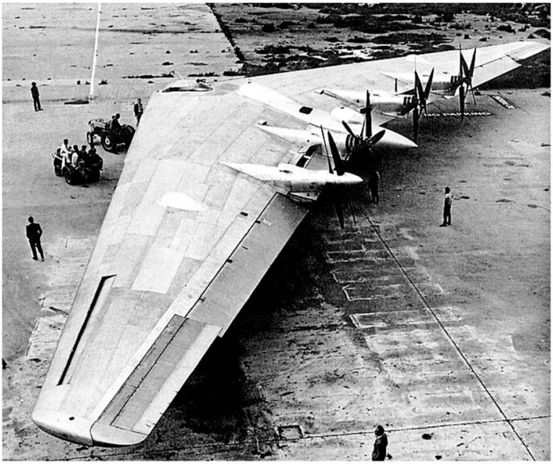
The N-9MB is today preserved by the magnificent Planes of Fame Museum at Chino in California, and is regularly flown. **Constance Redgrave.**

Jack Northrop leaning on the nose of the N-1M talking to test pilot Moye Stephens, shades of the earlier flying wing experiments. **Northrop**

CONTRACT WORK

During the Second World War, Northrop was to undertake a great deal of contract work for other companies. The rapidly developing factory had been asked by Reuben Fleet of Consolidated Aircraft to build the tailplanes of the PBY Catalina flying boat. Fleet had moved Consolidated to San Diego in 1935 and was to build over 4000 of the type for the US Navy and other users, so this was a contract that was to last the entire war.

As war production of military aircraft got up to full speed, bottlenecks began to appear in the building of several types. One of these was the Vultee A-31, later A-35, Vengeance dive bomber, which was being produced under licence at Stinson's Nashville plant. Stinson was working flat out because Vultee's Downey plant was busy producing the BT-13 trainer. In order to complete a British order for the dive bomber, Northrop was given a licence to build 400 Vengeance Mk.Is and Mk.IAs, a contract completed by 1944. Moye Stephens was the chief of production test flying and the 400 aircraft left the factory fully tested without a single accident. Northrop also produced thousands of sets of engine cowlings and nacelles for the B-17 bomber which were supplied to the production lines at Boeing, Lockheed and Douglas from 1942 to the end of the war. These were built at Plant 1 and the new Plant 2 at Hawthorne initially, and later at a large building in Los Angeles on Olympic Boulevard rented for the purpose. Lastly, the Hawthorne airfield at the plant was used to accept North American AT-6 Texan trainers, flown in from licence production lines. Here, they were dismantled and crated for shipment overseas.


The prototype XB-35 on the pan at Hawthorne, the staff giving scale to the huge aircraft. Three of the spinners have yet to be fitted due to problems with the gearboxes. **USAF**

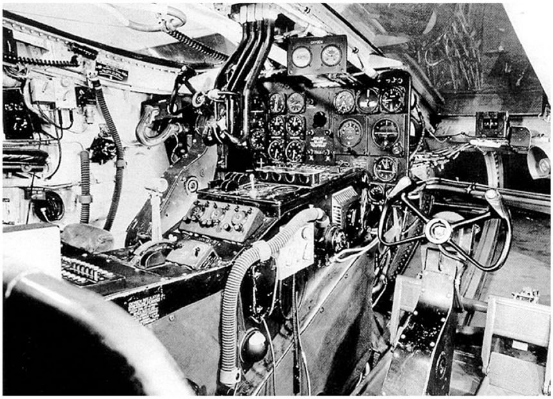
THE BLACK WIDOW

As well as the licence work, Northrop was to design and build one of the most unusual fighters of the Second World War, the P-61 Black Widow night fighter, named for the spiders the design team had had to avoid in the Hawthorne Hotel.

In September 1940, a British Mission had traded research on ground based and airborne radars at the same time as a Purchasing Commission issued an urgent requirement for a high altitude, high-speed night fighter with a loiter time of at least eight hours. Jack Northrop was briefed on the British requirement and began thinking of a large twin-engined design to meet the performance needs.

Completely unrelated to the British requirement, on October 22, 1940, the USAAC issued a similar requirement in a meeting with Jack based on its exposure to the British airborne radar research. He was already a month into his design work which he presented to the USAAC, which accepted the proposal on November 5. The big twin-engined fighter took shape as a twin boom layout with a large central fuselage pod for the crew of three. A pair of 2000hp Pratt and Whitney R-2800 Double Wasp engines were chosen, as the new fighter would be heavy. Airbrakes, spoilerons and full span Zap flaps, named after Northrop engineer Edward Zap, gave the aircraft tremendously flexible speed control to prevent overshooting targets at night. In order to successfully attack modern armoured aircraft, four 20mm Hispano M2 cannons and four .50 cal (12.7mm) Browning M2 machine guns were to be fitted as armament, all in the fuselage, the cannons fixed and the machine guns in a turret above the fuselage. The SCR-720 radar with a range of nearly five miles was mounted in the nose and a General Electric GE2CFR12A3 gyroscopic fire control computer allowed either the gunner or radar operator to aim the weapons.

The prototype, designated XP-61, first flew on May 26, 1942. The 346th Night Fighter Squadron (NFS), a training unit in Florida, first received the YP-61 then P-61As in mid-1943, and the 422nd NFS first took the Black Widow into combat over Britain in February 1944. A total of 706 P-61s were built in three main variants, and 36 were built as the F-15A Reporter photo reconnaissance aircraft, serving in every theatre of the Second World War. Postwar, 16 aircraft were converted for use as meteorological research platforms, but the introduction of jet aircraft ended the operational use of the P-61 in May 1951. ➤


Inside the cockpit of the XB-35 from the copilot's seat. The pilot sat higher up on the left under the clear Perspex bubble canopy. **USAF**

On take off, the YB-49 was an astounding sight, when compared with the conventional aircraft of the day. **USAF**

The exhausts of the eight Allison J35 turbojets fitted to the first XB-35 converted to YB-49 standard. **USAF**

A YB-49 pictured over the Muroc desert, the four small fins replaced the side area of the drive shaft cowlings for the propeller driven XB-35. **USAF**

FLYING WINGS

While all this work was going on, Jack also began work on a new flying wing design, using Plant 3 at Hawthorne. In this work he was assisted by Dr Theodore von Kármán, a Hungarian aerodynamicist and director of the Daniel Guggenheim School of Aeronautics at the California Institute of Technology (CalTech) who had founded the Jet Propulsion Laboratory at Pasadena. Von Kármán began spending two days a week at Hawthorne, not only working on the flying wing concepts, but also assisting with a new gas turbine engine design proposed by Northrop development engineer Vladimer Pavlecka. Jack and von Kármán were also assisted by one of von Kármán's students from CalTech, Dr William Sears, who had become the chief of aerodynamics at Northrop.

The first proper Northrop flying wing design, the N-1M, had a centre fuselage of welded tubular steel, mounting a pair of 65hp Lycoming four-cylinder engines, which were changed to a pair of 117hp Franklin six-cylinder engines during flight testing. The wings were built of plywood, which allowed for rapid changes in configuration as the flight trials revealed the characteristics of the concept.

Northrop chief test pilot Vance Breese made the first flight of the N-1M on July 3, 1941, the flight envelope of the 'Jeep', as it was known, being expanded over a careful series of trials conducted by Moye Stephens. Modifications were made to the control system and surfaces, and with each flight more data was collected until Jack was certain they had the basis for a successful flying wing aircraft.

Four months before the first flight of the Jeep, on April 11, 1941, the USAAC issued a new specification for an ultra-long range bomber, capable of carrying the war to Germany from the United States should Britain be invaded. The new aircraft was to be able to fly 10,000 miles (16,100km) at a cruising speed of 275mph (442kph) and be capable of reaching a maximum speed of 450mph (725kmh) and a ceiling of 45,000ft (13,720m). Originally offered to Boeing and Consolidated, as they were building the B-17, B-24 and B-29 heavy bombers, Northrop also replied to the specification in May 1941 with a proposal for a giant flying wing bomber, known as the XB-35.

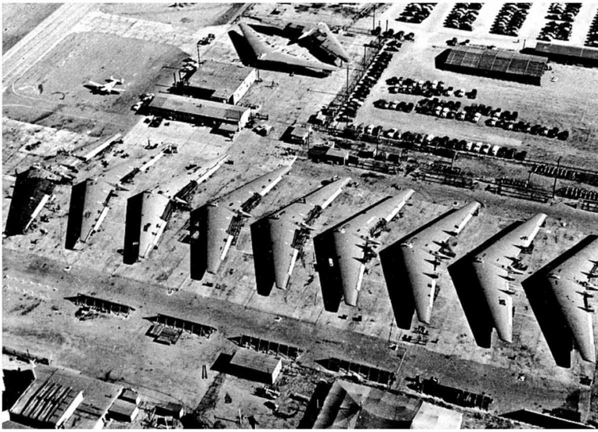
Although the Jeep was yet to fly, Jack was certain he could build an aircraft to meet these performance requirements using a flying wing to maximise the efficiency of the bomber. The USAAC witnessed several of the Jeep flight trials and was also convinced, issuing a contract for a single prototype in November 1941, expanded to include a second aircraft in January 1942. Jack was finally going to get to build his dream.

EXPERIMENTS AND THE N-9M

The contract for the XB-35 included a requirement for a one third scale, 60ft (18.3m) wingspan version of the aircraft to be built to prove the concept. Designated the N-9M, this was essentially a scaled up version of the N-1M design, with a welded tubular steel fuselage and again, plywood wings to allow rapid changes of configuration to be made in the light of test data as the programme evolved. In early 1943, the test programme was contract expanded to included two more N-9Ms, with a fourth being added a few months later. The first three, the N-9M-1, -2 and -2A, were powered by a pair of 275hp Menasco C6S inline six-cylinder engines, but the last aircraft, the N-9M-B, had a pair of 300hp Franklin XO-540s, as the Menasco

The YRB-49A in flight, the underwing engine pod just visible. **USAF**

One XB-35 was converted to the sole YRB-49A as a long range photo reconnaissance aircraft, seen here dropping a photo-flash bomb. **USAF**



The end of a dream. Eleven of the 15 flying wings on the pan at Hawthorne, the work to change from propellers to jets obvious on several of them. These were all scrapped, only three of them ever flew. **USAF**

engines had been prone to overheating and other mechanical problems during the test flying programme.

John Myers made the first flight of the N-9M-1 on December 27, 1942, the first of 45 flights over the next five months. The wing was fitted with hydraulically actuated flaps and elevons for pitch and roll control. Because of the lack of a rudder, yaw control was provided by a split elevon near the wingtip, which operated as an elevator and aileron in the normal sense, but would open up to provide asymmetric drag on one wing for yaw control when the rudder pedals were moved. Except for continual problems with the engines, the aircraft flew extremely well, Jack himself flying in it by kneeling on the floor behind the pilot. Sadly, during a spin recovery trial on May 19, 1943, test pilot Max Constant was killed when the N-9M-1 suffered control reversal and would not recover. This resulted in modifications to the hydraulic control system in the remaining three N-9Ms to prevent a reoccurrence. The N-9M-B survives to this day, and is regularly flown at the superb Planes of Fame Museum at Chino in California.

While the flight trials were continuing, detail design work on the 172ft (52.2m) wingspan XB-35 bomber was begun in early 1942. The entire structure was the multicellular stressed aluminium skin design for which Northrop had become famous and utilised a new and stronger aluminium alloy form Alcoa. Accommodation for a crew of nine was included in the 'fuselage' section in the centre of the wings, which was tall enough for a man to stand upright and was fitted with bunks for off-duty crew members. Remote sighting stations for three gunners would control four outer wing turrets and two fuselage turrets. For tail defence a seventh turret was mounted in the tail cone. Power was provided by four 3000hp Pratt and Whitney R-4360 Wasp Major engines driving pusher propellers, originally intended to be six-bladed contra-rotating units, but gearbox and vibration problems meant that normal three bladed units were substituted early in the flight test programme.

This and other delays meant that the delivery date of November 1943 was impossible to meet, but the USAAC still ordered 13 YB-35s from Northrop on September 30, 1943, and issued a production contract to the Martin Company of Marietta, Georgia, for 200 B-35s the same year. However, when it became clear the aircraft would not be ready before the war's end, the production contract was cancelled in May 1944.

The first XP-56, or Black Bullet as it was known, with the original small upper fin. **USAF**

FIRST FLIGHT, LAST FLIGHT

The first XB-35 was rolled out of the Hawthorne factory in 1946, making its first flight on June 25 that year, two and a half years behind schedule. Max Stanley was the pilot, Fred Bretcher the co-pilot and Orva Douglas the flight engineer on this momentous occasion, making a 45 minute flight to Muroc Dry Lake without incident. Unfortunately, the triumph was not to last long. After only 19 flights with the first aircraft and eight flights with the second, the aircraft were grounded and the propellers were changed for the simpler four bladed units, which reduced the climb rate and speed of the bomber, but also reduced the number of in flight power failures the XB-35 had been suffering.

The second XB-35 had joined the flight test programme at Muroc a year after the first, but the change to the propulsion system was causing vibration and instability problems. ➤

However, the stall and stall spin recovery of the giant wing was found to be quite acceptable, as was the general handling despite its unusual appearance.

With the advent of the jet engine, the XB-35 was considered obsolete, the first aircraft being scrapped on August 23, 1949, following the second aircraft which had met the same fate four days earlier.

Production of the 13 pre-production YB-35s began, despite the powerplant problems, the first one flying on May 15, 1948. All 13 were built, but only the first one flew as a propeller driven YB-35, proving its airworthiness in a number of test flights, before it was scrapped on July 20, 1949, having sat on the ground for almost a year. The second YB-35 wasn't even finished when it was scrapped on August 19, 1949, as it had been too far into the production process with propellers to economically convert to jet propulsion.

The XP-79 was supposed to be rocket powered, but problems installing the engine led to a pair of 1150lb (522kg) thrust Westinghouse J30 turbojets being fitted instead. **USAF**

ENTER THE JETS

Of the 11 remaining airframes, two were converted to be powered by eight Allison J35 turbojets producing 4000lb (1815kg) of thrust each. Redesignated the YB-49, the aircraft made its first flight on October 21, 1947, and was instantly recognised as a far more capable aircraft than the propeller driven version. The high performance of the flying wing was instantly apparent, reaching a maximum speed of 495mph (793kmh) and a ceiling of 45,700ft (13,900m), although the increased fuel consumption of the jet engines had reduced the combat radius to less than half that of the rival Convair B-36 Peacemaker.

During testing, the second YB-49 was lost on a test flight on June 5, 1948. Both outer wings detached from the centre section during a 4.8G recovery from a dive after a stall test, killing the crew of five, which included co-pilot Captain Glen Edwards, after whom Edwards Air Force base is named.

The first YB-49 did achieve a number of notable successes, not least of which was on February 4, 1949, when it was flown from Muroc to Andrews Air Force Base near Washington DC in only four hours and 25 minutes. On the way back to Muroc, four of the engines had to be shut down because the oil reservoirs had not been filled when the aircraft overnighted at Wright Field, causing the engines to overheat and catch fire. Sabotage was suspected but never proven. One of the criticisms aimed at the flying wing, that of directional instability, was highlighted in bombing trials with this aircraft, which it was said needed a long bomb run to damp out any excess oscillations in yaw. In response, Northrop was already talking to Honeywell about a new autopilot with yaw damping to correct this flaw. Before this could happen, this aircraft too was lost, on March 15, 1950, during a taxi trial at Muroc which took place at high all up weight with the aircraft's fuel tanks full, a very unusual occurrence. The nosewheel collapsed and the airframe was consumed in the ensuing fire, but all aboard managed to safely exit the aircraft. Coincidentally, the entire flying wing bomber programme was cancelled by the United States Air Force on the same day as the accident.

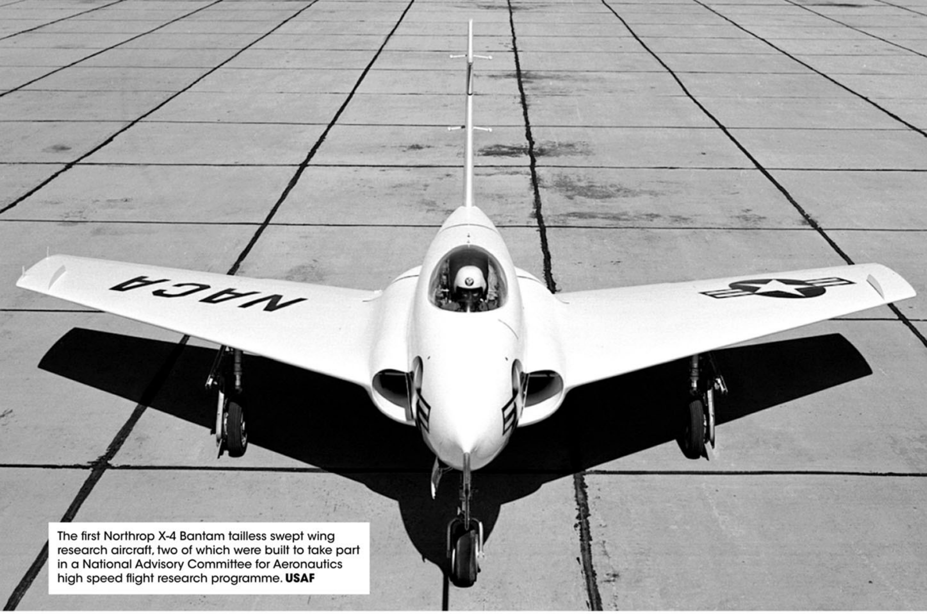
One more YB-35 was converted to jet power becoming the sole YRB-49A, fitted with six upgraded 5000lb (2268kg) thrust Allison J35 turbojets, four in the wings and two in underwing pods outboard of the undercarriage. This arrangement, while it did nothing for the aerodynamics, improved the internal fuel capacity of the airframe which was intended as a long range reconnaissance aircraft. Thirty had been ordered into production in September 1948 as the RB-49A, but then cancelled only two months later as it was realised the emerging Boeing B-47 and B-52 jet bombers could be adapted to the role without the need for a dedicated aircraft. The first flight of the modified aircraft took place on May 4, 1950, the last, only 13 flights later, on April 26, 1951. The last of the big flying wings left, it was scrapped on December 1, 1953. Jack's flying wing dream was, for the moment, dead.

Much has been written about the cancellation of the flying wing programme. It has been suggested that political machinations by the Secretary of the Air Force, Stuart Symington, sabotage, unfair trials, false reports and lobbying by Convair for the B-36 in Washington all played a hand in the end of the programme. These allegations are equally countered by those who point out that the aircraft was late and over budget, the thick wing section limited its maximum speed, the complex engine and exhaust installations were prone to failure, and the control system available at the time was not up to the task of finessing the handling of the big bomber in either jet or propeller driven form.

Lastly, the end of the Second World War cut the military budget to a tiny percentage of its wartime might, so choices had to be made. Yes, it was an extremely high performance and very efficient aircraft for the time, but in the face of more conventional competition the benefits were far outweighed by the technical difficulties yet to be overcome, it was too far ahead of the technology of the day is the conclusion of some reporters. So what is the truth? Frankly, I believe that some of the allegations of bias against the XB-35 and 49 are true. There were a number of very odd occurrences during the programme which do seem to suggest a darker hand was being played.

The lack of oil in four randomly placed engines of the XB-49s on the way back from the record breaking flight to Washington, the fully fuelled taxi trial that later destroyed it, the air force's insistence on all the aircraft being cut up and melted down in portable smelters brought to Northrop's factory, and the refusal to donate even one of these ground breaking aircraft to the Smithsonian for preservation all combine with other elements to leave the impression that there was more to this cancellation than just the limitations of technology. I am prepared to admit that this is just an impression, that these events may have completely innocent explanations, but the end result of this combination of odd occurrences is undeniable.

The second XP-56 with an enlarged upper fin in an attempt to cure its directional instability. **USAF**

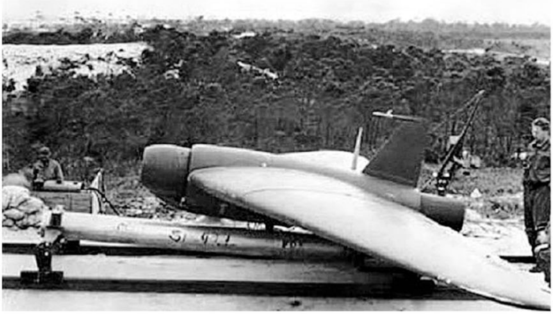


The first Northrop X-4 Bantam tailless swept wing research aircraft, two of which were built to take part in a National Advisory Committee for Aeronautics high speed flight research programme. **USAF**

OTHER WINGS

It may seem incredible, but there were yet other flying wing designs occupying Jack and the Northrop team during the Second World War. The first of these was the Northrop N2B concept of 1939, a startling concept for a flying wing fighter powered by a pusher contra-rotating propeller. The USAAF ordered a single prototype on September 26, 1940, including a second aircraft five months later. The N-1M flying wing trials aircraft produced a great deal of the aerodynamic data that confirmed the viability of this novel fighter concept, which was to be built of magnesium to avoid further drains of the already overstretched aluminium industry.

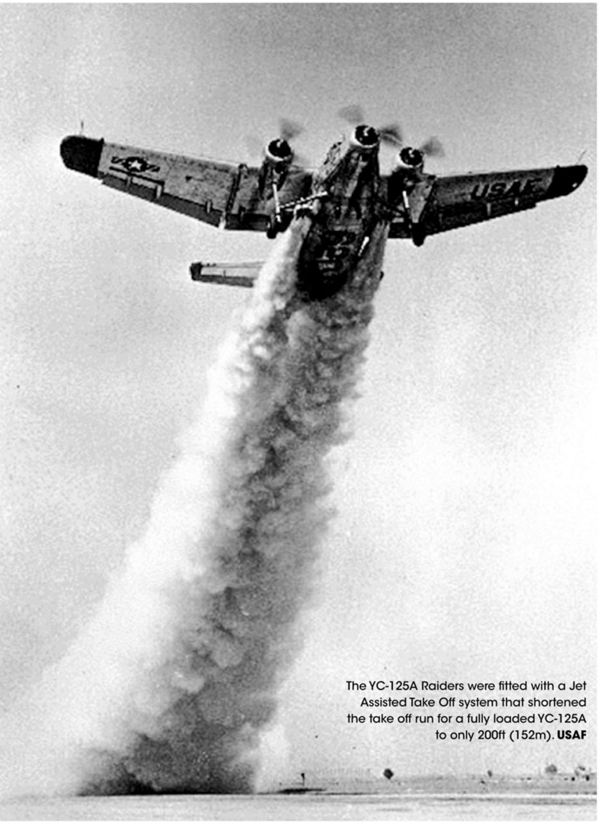
Northrop engineers Vladimir Pavlecka and Tom Piper had developed a technique to weld magnesium, which normally burst into flames when this was attempted, using helium to surround the welding flame, known as Heliarc welding. Using this technique, the first XP-56, or Black Bullet as it was known, was built and made its first flight on September 30, 1943. Powered by a 2000 hp Pratt and Whitney R-2800 Double Wasp engine, the stubby fighter was capable of 465mph (749kph), but suffered from directional instability, causing the upper fin to be enlarged as part of an ongoing modification programme. The first aircraft was destroyed in a crash during a taxi trial at Muroc Dry Lake on October 8, 1943, ending the development until the second aircraft made its first flight on March 23, 1944. The aircraft never flew satisfactorily, despite being continually modified, so the project was abandoned in 1945 as jet developments made the propeller driven fighter obsolete.



Eight JB-1s were converted to pulsejet power using the Ford PJ-31-1 engine as seen here. **USAF**

Next was the XP-79, a 1942 proposal for a rocket powered flying wing fighter not unlike the Messerschmitt Me 163 Komet. The USAAF agreed to fund the building of three glider versions of the aircraft to test the concept, the first MX-334, as they were known, flying in October 1943 after being towed into the air by a Lockheed P-38 Lightning. The pilot lay on his stomach, his head supported by a V shaped strut, to minimise the effects of G during high speed manoeuvring. The first rocket powered flight, again towed in to the air by a P-38, was made on July 5, 1944, using an Aerojet rocket motor which produced 427lb (194kg) of thrust. In its powered form, the trials aircraft was known as the MX-324. The intended engine for the XP-79 was the 2000lb (907kg) thrust Aerojet XCALR-2000A-1 rotojet motor using monoethyl aniline and red fuming nitric acid as fuel. Because of the corrosive nature of the fuels, the aircraft had a welded magnesium alloy monocoque fuselage to protect the pilot from the fuel. The rocket motor installation proved unsatisfactory, so the single prototype of the fighter was built with a pair of 1150lb (522kg) thrust Westinghouse J30 turbojets instead. This was designated as the XP-79B, but known as the Flying Ram as it was intended to ram enemy aircraft in flight. On the first flight on September 12, 1945, test pilot Harry Crosby was killed when control was lost and he bailed out, only to be struck by the aircraft which prevented him from opening his parachute. The project was cancelled. ➤

Several YC-125A Raiders ended up as originally intended with civilian transport operators in South and Central America, such as this one preserved at the Pima Air Museum in Arizona. **Constance Redgrave**



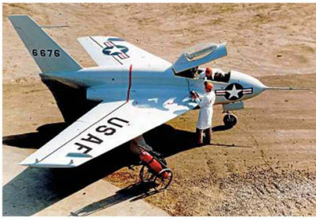
The YC-125A Raiders were fitted with a Jet Assisted Take Off system that shortened the take off run for a fully loaded YC-125A to only 200ft (152m). **USAF**

The last of the wartime flying wing projects was the Northrop JB-1 Bat or Bat Bomb was an attempt to produce a flying wing unmanned jet powered flying bomb as part of the USAAF's MX-543 programme of September 1942. A manned glider version was towed up for its first flight in the hands of Harry Crosby in early 1944 at Rogers Dry Lake and flew well. Two trials in December 1944 with the unmanned version, one powered by a General Electric B-1 tubojet, the other a glider but launched on a rocket sled, resulted in crashes. The remaining eight JB-1 airframes were converted to pulsejet power using the Ford PJ-31-1 engine and several were tested at Muroc and Eglin Air Force Base in 1945 before the programme was cancelled in January 1946. One airframe survives and is on display at the Western Air Museum.

One more almost flying wing design was produced, the Northrop X-4 Bantam of 1948, two of which were built as part of a NACA high speed flight research programme. Two 1600lb (726kg) thrust Westinghouse J30 turbojets powered the tailless swept wing aircraft, giving it a maximum speed of 640mph (1035kph) as it was intended to research the transonic suitability and behaviour of tailless designs. The first X-4 was delivered to Muroc and flew on December 15, 1948, but after 10 flights was grounded due to mechanical reliability problems. The second aircraft fared much better, flying trials for the USAF and NACA from 1949 to September 29 1953. Many famous pilots flew the X-4, including Charles 'Chuck' Yeager, Jack Ridley and Fred Ascani. The first aircraft was used to supply spares for the second, and both survive today, one at Edwards Air Force Base, the second at the USAF Museum at Wright Patterson Air Force in Ohio.

TRANSPORTS AND MISSILES

After the cancellation of the flying wing bomber programme, the Northrop Corporation had found a great deal of contract work converting military Douglas C-47 transport aircraft back into DC-3 airliners for the rapidly growing civil airline market. This at least generated income while the firm considered its next move and the Scorpion was being developed. Experience of the growing civil transport market, and a tour of South American countries by La Motte Cohu and Ted Coleman, suggested that a new three



The second Northrop X-4 Bantam being prepared for flight testing at Muroc in 1949. **USAF** engined short take off and landing transport aircraft would be very successful in allowing regional airlines to link towns with short and rough field airstrips, both abroad and in the US. Using three cheap, war surplus 1200hp Wright R-1820 Cyclone engines, the 36 seat Northrop N-23 Pioneer first flew on December 21, 1946. Despite the good short field performance, the new transport could not compete in a marketplace full of inexpensive ex-military aircraft, echoing the experience of Jack's first design for Lockheed, the S-1 sportplane after the First World War.

The prototype crashed in 1947, killing test pilot Slim Perret, but in 1948 the USAF ordered 23 of the type in two versions, 13 YC-125A Raider 30 seat troop transports and 10 YC-125B Arctic rescue aircraft. The aircraft were found to be underpowered when deliveries to the USAF began in 1950. They were fitted with a Jet Assisted Take Off system that shortened the take off run for a fully loaded YC-125A to only 200ft (152m), but by 1955 had been retired. Several ended up as originally intended, flying with local air services in South and Central America.

In the same year the N-23 first flew, work also began on two long range cruise missile designs intended for the nuclear deterrent forces of the US Air Force. Developing the work begun in the earlier USAAF MX-543 flying bomb programme, two programmes for new missiles were proposed, the subsonic MX-775A Snark and the supersonic MX-775B Boojum, both names taken from the Lewis Carroll poem The Hunting of the Snark. Technical difficulties in the development of the 50ft 10in (15.49m) span delta-winged supersonic Boojum led to it being cancelled in 1951 before any had been built, but the subsonic Northrop SM-62 Snark was developed into a fully operational weapon system.

A Northrop F-89H, 52-1938 armed with Hughes AIM-4 Falcon missiles on the wing tip tanks. **USAF**

The Snark had a swept wing with a span of 42ft 3in (12.9m) and was launched by a pair of Aerojet rocket boosters that produced 130,000lb (58,967kg) of thrust to accelerate the missile from its launch platform. In the cruise, it was powered by a 10,500lb (4763kg) thrust Pratt and Whitney J57 turbojet, which gave the missile a speed of 650mph (1046kph) and a range of 6330 miles (10,200km). In order to guide the missile to its target, Northrop developed the lightweight MEDIDA computer for celestial navigation, a system that effectively founded Northrop's new electronics division. Once over the target, the forward section of the missile separated and assumed a ballistic trajectory. The missile could also be launched and instructed to loiter for up to 11 hours, before returning to base to make a belly landing so it could be reused.

This feature made the Snark system less vulnerable to being destroyed by a first strike before it could be used. The first of these complex missiles were delivered to Patrick Air Force Base in Florida in January 1958, whereupon training began to form the 702nd Strategic Missile Wing of Strategic Air Command (SAC). Despite many failures and technical problems with the missile and its systems, the 702nd was established at Presque Isle Air Force Base in Maine, receiving its first Snark on May 27, 1959. Thirty missiles were deployed, being declared operational in February 1961. Because of the long development time caused by its new and advanced systems, the Snark was declared obsolete in March and the 702nd was deactivated June 25, 1961, having been in service less than three and a half years.

Formation of three F-89Ds, 52-1959, 52-2141 and 52-2138, of the 59th Fighter Squadron, Goose Bay, Labrador. The wing tip pods housed fuel and rockets in their forward half. **USAF**

SCORPION SUCCESS

In 1945 the USAAF issued a specification for a jet all-weather and night fighter to replace the P-61 Black Widow in service. Five companies responded to the requirement, as well as Northrop, who submitted no fewer than four initial designs, one of which was a flying wing. After consultations, a conventional, straight winged design, the N-24, was selected for development. The broad, shoulder mounted wing featured airbrakes called Decelerons. These were split ailerons, which could function as both ailerons and flaps, or open above and below the wing to perform as airbrakes. As with the earlier P-61, these were to allow the interceptor to approach a target at high speed then slow rapidly to prevent overshooting it. The prototype XP-89 as it was designated, was flown for the first time by Fred Bretcher on August 16, 1948. The tailplane was mounted high up the elegant fin to keep it out of the wing's airflow and jet exhausts. This feature led to the aircraft being dubbed Scorpion by the Muroc Dry Lake ground crews during flight testing, a name that was officially adopted.

The first production aircraft, the F-89A, flew in September 1950, 18 being built and delivered for further trials of the AN/APG-33 nose mounted radar and six 20mm Hispano ➤

T-31 cannons. Underwing racks could carry up to 16 5in (127mm) rockets or up to 3200lb (1455kg) of bombs to enable the fighter to fulfil a secondary ground attack role. Further developments in avionics led to the F-89B, which entered service with the 84th Fighter Interceptor Squadron (FIS) in June 1951. 40 of these were built, followed by 164 F-89Cs. A number of crashes were caused by wing failures, stemming from both cracked wing mounts and aeroelastic twisting of the wing under certain loads. The accidents meant the entire Scorpion fleet was grounded while new mounts were devised and the wing stiffened. These modifications were retrofitted to 194 in-service Scorpions, after which it had one of the safest service records of any fighter. Its slim fuselage contained two Allison J35 turbojet engines fitted with afterburners, producing 7200lb (3265kg) of thrust in the J35-A-35 version of 1951, giving the F-89D of that year a maximum speed of 635mph (1022kph). Altogether 1050 Scorpions were built, with a variety of radars, avionics and fire control systems, along with armaments ranging from 104 2.75in (70mm) Mighty Mouse rockets in the F-89D, six Hughes Falcon radar and infrared guided missiles with 42 rockets in the F-89H, and a pair of Douglas MB-1 Genie nuclear air-to-air rockets with four Falcon missiles in the F-89J. The Scorpion served with the USAF until 1959 and the Air National Guard until 1969.

The F-89 Scorpion was significant in being the first successful jet aircraft mass produced by Northrop. It was also the last aircraft to be designed from the outset by Jack Northrop. When the wing problems were encountered, Northrops new chairman, Oliver Echols, insisted on bringing in engineer and designer Edgar Schmued to find a solution, against Jack's wishes as he was already working on the problem. Schmued had been the design leader on the P-51 Mustang and F-86 Sabre while at North American Aviation and was quickly named as assistant chief engineer by Echols, despite Jack's protests as he had been discussing the same position in the company with Eugene Root from Lockheed.

The cancellation of the flying wing programme had been a bitter blow, but now Jack found himself in a similar position to when his first company had been absorbed by Douglas. He was no longer in control of the company and becoming increasingly distanced from his true ambition, designing new and innovative aircraft. Jack resigned from Northrop in December 1952, a sad loss to the industry. Jack was to maintain his links to aviation when he acquired the Northrop Aeronautical Institute when it was offered for sale, becoming chairman of the Northrop Institute of Technology as it was known when it was moved from Hawthorne to Inglewood. In 1971, full college accreditation meant that the Northrop University was founded adding law and business to the technical and engineering curriculum.

At this point, the N-156 project was to start development at Northrop, under chief of advanced design Welko Gesich. This would lead to the T-38 and F-5, as will be discussed in this magazine. Later, Northrop would go on to merge with Grumman to form the Northrop Grumman Corporation in 1994, one of the largest aviation, space, naval and defence companies in the world. They would produce a wide variety of platforms, from strike aircraft and fighters to stealthy UAVs, a business that continues to this day, but in 1979 began development of the Advanced Technology Bomber, the project that would become the Northrop Grumman B-2 Spirit, commonly known as the 'stealth bomber'. The long range heavy bomber is a pure flying wing, drawing on much of the engineering and aerodynamic experience gained on the XB-35 and 49 projects. In May 1980, Jack Northrop, in failing health, was invited to see the top secret designs and view a model of the B-2. As he looked at the material, it was as if the years fell from the frail man. Ten months later, on February 18, 1981, Jack Northrop died peacefully in hospital, aged 86. His legacy lives on today, in no uncertain terms. The wingspan of the flying wing B-2 bomber is 172ft (52.4m), as was the XB-35. ■

Words: Tim Callaway

The Northrop Grumman B-2 Spirit in flight. It has the same wingspan as Jack Northrop's XB-35 and 49. **USAF**

A pair of B-2s approaching a KC-10 tanker. Jack Northrop saw the secret drawings and models of the stealth bomber just before he died, seeing his dream reborn. **USAF**

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Fang & Talon

The beginnings of the Northrop N-156 project

Production of the Northrop F-89 Scorpion was in full swing in early 1950 and other advanced designs were taking shape all over the country. Heavy, powerful and complex aircraft were the order of the day, but the Northrop management team decided to go a very different way, refining an idea for a light, simple and most importantly inexpensive fighter design. Interestingly, it was the two seat trainer version of this design that was to take the lead.

With the departure of Jack Northrop from the company in 1952 as previously related, Edgar Schmued became vice president in charge of engineering. He prompted a study into a lightweight, simple but supersonic fighter design, to be known as the N-102. At the time, there was an increase in complexity and operating costs of many modern combat aircraft and their systems and it was foreseen that many countries could not afford these, or if they could, only in very small numbers.

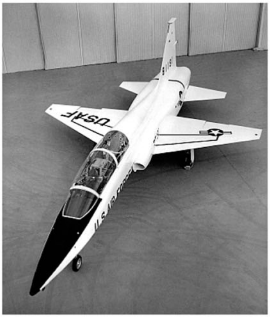
Other companies were looking at the light fighter concept as a way to provide friendly countries with affordable and effective air power, the Italian Aerfer Sagitario II and the British Folland Midge were two such designs. In 1954, NATO held a design competition for a lightweight fighter, but even though several prototypes were produced, the competition came to naught. However, it did prove that both an interest in and a market for such an aircraft existed.

Welko Gasich, then chief of advanced design, headed the Northrop study team, with designer Lee Begin producing the project drawings. The first design to emerge from his drawing board in 1952 was a high wing tailed delta, powered by a single large turbojet with an air intake below the fuselage, known as the Fang. In 1954, a complete mock up of this striking aircraft was completed, along with detail drawings for a stretched two seat training version.

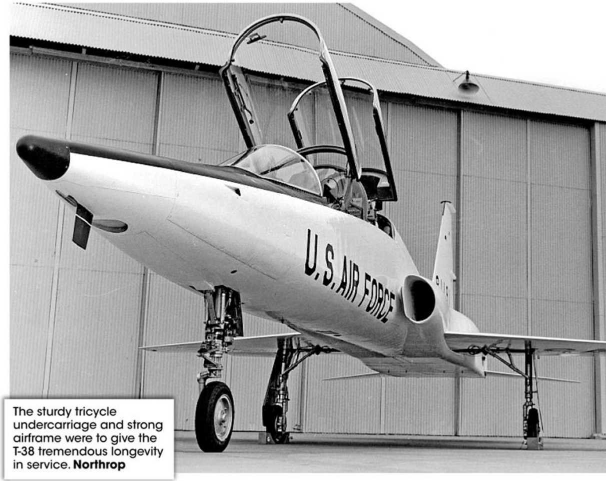
There were a number of problems with the design as completed. Yes, it was simple and relatively lightweight at roughly 16,000lb (7258kg), but the single powerful turbojet engine would be expensive to operate and would require a great deal of fuel. At this point, Tom Jones, who was now Northrop's planning officer and would go on to become its president, took a hand and changed the emphasis of the programme, suggesting that investigation of the lowest cost solutions available was the way forward.

Welko Gasich agreed, adding the concept of minimising the life cycle costs over the entire service life of the new fighter, a new approach which was to contribute greatly to the type's later longevity and success. Fortunately, at the time, a number of missile projects had prompted the development of small turbojets with high power to weight ratios for the time. One of these was the General Electric J85 being built for the McDonnell GAM-72 Quail, a decoy missile which had the same radar cross section as a

The first three YT-38s often flew with covered rear canopies as the back cockpits were full of test and measurement equipment. **Northrop**



The first YT-38, 58-1191, shows its clean lines and short, trapezoidal wings. **Northrop**



The sturdy tricycle undercarriage and strong airframe were to give the T-38 tremendous longevity in service. **Northrop**

bomber, to be launched by the Boeing B-52 Stratofortress. It was decided that two of these engines would make the ideal powerplant for a small, lightweight fighter, so the Northrop design team focused its efforts on aircraft based on these small jets. This choice reduced the weight as well as the fuel consumption and operating costs, but was to nearly be the undoing of the whole project, as will be explained later.

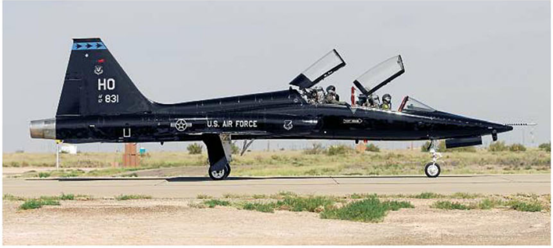
In 1955 the Northrop team began work on a series of designs that expanded on this twin engined concept, known as the N-156. The first of these was the N-156TX of March 1955, engines in nacelles under an unswept wing. Performance studies of the design were disappointing, so it was rejected and the team began work on the N-156NN with engines mounted in the fuselage, fed by separate air intakes. This was intended as a light naval fighter, so was strengthened for carrier operations and featured a T tail and full span flaps. However, the withdrawal from service of the US Navy's escort carrier fleet, the size of carrier for which the aircraft was designed, curtailed interest in the project.

This was followed by six more single and two seat configurations in 1956, the last of which, PD-2879D, was a two seat design to give the new fighter a training capability, and was very similar to the aircraft that was to eventually emerge. Wind tunnel models were used to finally determine the degree of area ruling required by the rear fuselage, resulting in a distinctive 'waisted' appearance to the design. Alongside this two seat aircraft, a single seat derivative was also being produced, given the designation N-156F, the two seater being known as the N-156T.

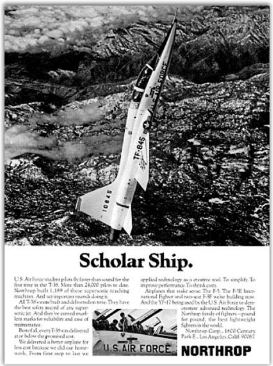
Northrop's interest in a two seat design had been prompted by a US Air Force (USAF) requirement issued in 1955, for a supersonic trainer to replace the Lockheed T-33 Shooting Star then in service with the Air Training Command. The N-156T layout was proposed to the USAF in March 1956 as a response to the requirement, the twin engined layout offering a high safety factor in a trainer. Three prototypes were ordered in July 1956, the new aircraft given the designation YT-38 and named Talon, but any future orders rested on the proviso that the prototypes flew successfully.

As the engineering mockup of the N-156T was being built, a number of revisions were incorporated in the design. The original ventral fin was dropped and a larger fin was fitted to maintain the side area of the aircraft. Jet trainers at that time all suffered from having the instructor's seat directly behind that of the pupil, restricting his view of what the aircraft was actually doing and limiting his ability to teach from obvious errors. Northrop had originally proposed a mechanically drooped nose to provide a better view on landing, but this was deemed too expensive and heavy, so instead the instructor's seat was raised by 10in (25.4cm) which gave him an excellent view, a much admired feature of the aircraft for many years and a relief to many instructors.

The ailerons and rudder were powered, as was the all flying tailplane, power for the hydraulic system being taken from both engines to provide redundancy. Control 'feel' was provided by a simple system of springs ➤



Not all white rockets were white, as evinced by this Holloman based T-38A. **Keith Draycott**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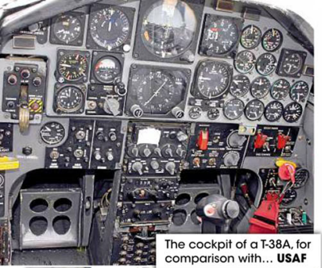
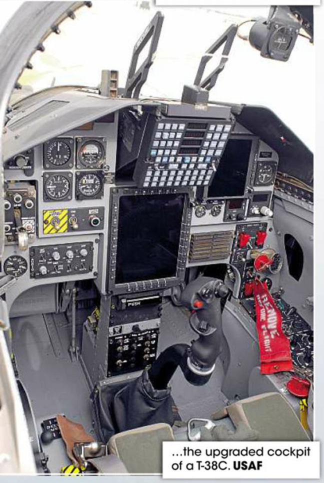
NORTHROP

An advert from 1974 for the T-38 tells the remarkable story. **Luigino Caliaro**



The cockpit of a T-38A, for comparison with… **USAF**



…the upgraded cockpit of a T-38C. **USAF**

and counterweights and the entire control system was fitted with stability augmentation. The airframe was made to be extremely strong, as was the undercarriage, to allow for mishandling by students. This integral strength was another feature that would add to the trainer's subsequent long service life.

As the prototype YT-38s took shape at Hawthorne, a major problem arose that could have brought the whole programme to a halt. The General Electric (GE) J85 engine had been designed for a subsonic decoy missile, it was never intended to withstand the stresses of full flight or be fitted with an afterburner. Testing with the new version of the engine had revealed that a redesign of several components was needed.

Delays followed, then an increasingly frustrated USAF gave both GE and Northrop a deadline of April 11, 1959, to fly the YT-38, or the engine would be cancelled. This was a serious blow to Northrop, as it had designed the slim fuselage around the 17.7in (45cm) diameter and 45.4in (115cm) length of the small engine, changing to another would require almost a complete redesign of the rear fuselage and air intakes. Everyone realised what was at stake, as any order for the trainer was likely to be in large numbers. GE's vice president, Cramer LaPierre, assured Northrop that the engine would reach the promised 2500lb (1134kg) dry thrust output, increasing to 3650lb (1656kg) with afterburner.

GE's engine group engineering manager, Ed Woll, led a team of engineers to solve the problems of the engine one by one. As the deadline approached, two things became obvious. Firstly, all the engine problems were solved and just required testing, but secondly, the fully developed afterburning engine would not be ready in time. Northrop decided to stay with the promise of the J85, fitting the prototype YT-38, 58-1191, with a pair of non-afterburning YJ85-1s which produced only 1900lb (862kg) of thrust. The prototype was transported to Edwards Air Force Base, and on April 10, 1959, one day before the deadline, Northrop's chief engineering test pilot Lew Nelson made the first flight.

Despite being down on power, the YT-38 reached Mach 0.9 and a height of 35,000ft (10,668 m) in the 42 minute flight, which Nelson recorded as the "cleanest first flight in my experience". On April 15, the YT-38 exceeded Mach 1 in a shallow dive without incident and it became evident that Northrop had produced a superb aircraft. Its handling and characteristics were excellent and benign, recovery from a stall being a smooth nose drop to regain flying speed, even hands off, rare in a short wing jet. The second YT-38, 58-1192, joined the flight test programme on June 12, again powered by the YJ85-1 engines. The third prototype was delayed until January, but was fitted with the first J85-5 afterburning engines which delivered the thrust the GE had promised. This aircraft was 58-1194 the first production standard T-38A and the low operating costs, Mach 1.3 performance, twin engined safety factor and superb handling it delivered were all the USAF had wanted from the trainer.

In October 1959, four more T-38As were ordered, followed by 13 more in December. This was to be the beginning of a series of orders that would eventually mean 1189 T-38s were built. The sheer number of aircraft on order necessitated Northrop installing a moving production line called the Norail at the Hawthorne plant. The efficacy of the wind tunnel testing phase of the design, prior to the first flight, meant that throughout the T-38's

production, very few minor changes were made to the type. These included an under-fuselage metal plate to protect the engine nozzles and the addition of a secondary air intake on either side of the fin fillet on the upper fuselage to provide cooling air for the afterburners.

The T-38's stellar performance quickly started setting records, in 1962 time to climb records to 3, 6, 9 and 12,000m were set, beating those of the F-104 set in 1958. Jacqueline Cochran, who had purchased a Northrop Gamma in the 1930s, also flew the T-38, establishing records for speed over a 15km course and a 100, 500 and 1000km closed circuit, as well as reaching a sustained altitude of 55,253ft (16,841m) over a 25km course.

Four upgraded T-38C Talons fly over Randolph Air Force Base, Texas in April 2009 on the 50th anniversary of its first flight on April 10, 1959. In the five decades of service, more than 75,000 pilots had flown in a T-38 while earning their wings. **USAF**

Aside from the USAF, which was introducing the T-38 in substantial numbers, the first entering service on March 17, 1961, other organisations took an interest in the trainer. The Luftwaffe was the first of these, sending a group of German instructors on a T-38 familiarisation course in December 1962. In July 1965, Germany purchased 46 T-38As to be based in the US along with 47 German owned Cessna T-37Bs. The entire flight training course for Luftwaffe pilots took place in the US on USAF marked but German owned aircraft from that point on. Thirty-five T-38s are still in use by the Luftwaffe for this purpose today. NASA purchased 30 T-38s in May 1964 to help maintain the pilot proficiency of the astronaut corps.

Astronauts Neil Armstrong and Elliot See had both been involved with the test and development programme of the T-38 and the derivative F-5 so were already familiar with the type. The air forces of Portugal, Turkey and the Republic of Korea were also to use the trainer, Portugal leasing 12 between 1977 and 1993, Turkey purchasing 73, the first being delivered in 1979 and Korea leasing 30 aircraft between 1999 and 2009. During the third production batch of the trainer, it was decided to supply small numbers of T-38s with an additional weapons carriage capability by way of a centreline pylon under the fuselage similar to that of the F-5.

This could carry the SUU-20A practice bomb and rocket carrier or a minigun pod and allowed weapons training to be carried out. In this guise, the aircraft was known as the AT-38B. Small numbers of the Talon were also converted for use as drone director aircraft (DT-38A), research and test aircraft (NT-38A) and as an unmanned supersonic target drone (QT-38A).

On January 7, 1969, the USAF accepted the 1000th T-38 into service, a remarkable achievement for the lithe trainer now universally known as the 'white rocket'. Such is the reliability and longevity of the hard wearing Talon that in 2001, the first upgraded T-38Cs were received into USAF service. These aircraft have undergone a complete avionics and propulsion upgrade along with structural modifications and revisions. The engines have had major components replaced to increase reliability and ease maintenance, as well as having the engine intakes in injectors modified to increase take off thrust.

The cockpit has a head up display and large multifunction display replacing most of the earlier instruments and allowing the T-38C to act as a lead in trainer to such advanced types as the F-22 and eventually the F-35. Although a replacement competition for the T-38 is running, known as the T-X, it is unlikely that the aircraft will be replaced before 2020, meaning that Northrop's elegant trainer will have been in service for nearly 60 years, a remarkable achievement by a remarkable company. ■ *Words: Tim Callaway*

The STS-134 crew of the Space Shuttle Endeavour arrive at the NASA Kennedy Space Center Shuttle Landing Facility in Cape Canaveral, Florida on April 26, 2011 in their T-38As. **NASA**

A Fighter for the

The N-156 to F-5 - Developing the international fighter

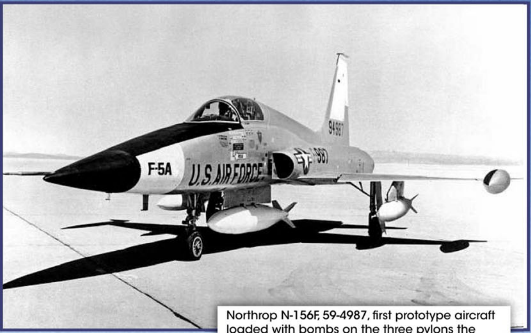
While the USAF's major interest in the N-156 programme was the two seat trainer version, work continued on the N-156F, the single seat fighter intended for the international market. This was to emerge as the F-5, and go on to be used by 37 countries worldwide, a second major success for Northrop which built 847 of the first three models of its lightweight design.

While the T-38 was in development, Welko Gasich and Lee Begin continued the design of the single seat version of the aircraft under the company designation N-156F. As more data became available from the trainer programme, this was incorporated into the fighter, resulting in a great deal of commonality between the two variants. As before, cost effectiveness and ease of maintenance were key factors in the design, as was structural strength, to allow overseas customers with tight budgets to maximise the number of aircraft they could buy as well as their length of service. Like the T-38, the entire rear fuselage detached at a sharply angled joint to enable easy access to the engines and their systems. A track and trolley was fitted into the top of each engine bay, to allow engineers to remove the engines for maintenance with the minimum of external equipment.

The engines themselves were mounted in the airframe complete with their attendant hydraulic pump, generators and gearboxes to form a single unit, again easing maintenance. The wing was fitted with the same leading edge slats and full span flaps of the trainer, but featured a leading edge root extension or LERX which increased the lift available and improved manoeuvrability in the fighter. This feature is the major identification difference between the types since the T-38 never had them. Two underwing pylons could be fitted, along with one on the fuselage centreline for the carriage of weapons or drop tanks, and 'waisted' wing tip fuel tanks could also be carried.

Armament for the fighter was based around two 20mm M-39 cannons, mounted First World War style in the upper fuselage ahead of the cockpit. One F-5 pilot once commented to

World



Northrop N-156F, 59-4987, first prototype aircraft loaded with bombs on the three pylons the type was originally fitted with. **USAF**

The second N-156F, 59-4988, seen here after August 9, 1962, when the aircraft officially became a YF-5A and was named Freedom Fighter. **Dave Menard**

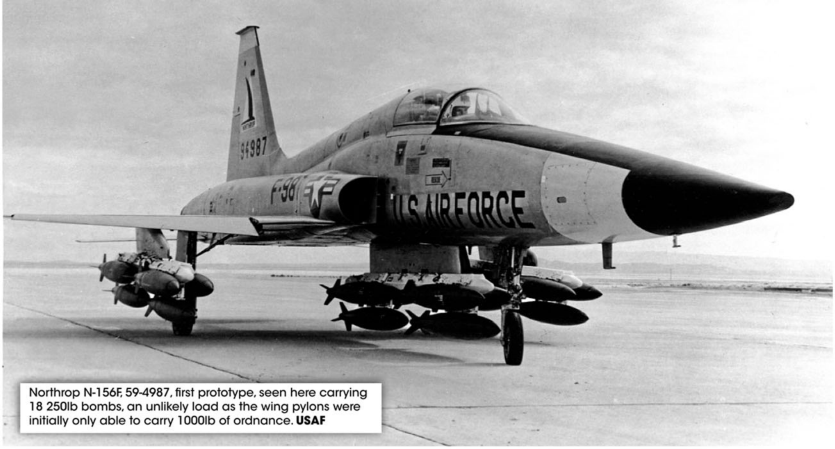
me that it was this feature alone, firing those guns ahead of the cockpit that made him really "feel like a fighter pilot". A pair of AIM-9 Sidewinder heat seeking missiles could be carried, one on each wingtip on a detachable rail that could be removed to fit wing tip tanks or to reduce drag. The centreline pylon could carry 2000lb (907kg) of ordnance, each of the wing pylons 1000lb (454kg) each. A wide range of bombs, rockets and missiles could be carried to allow the aircraft to operate in the interceptor or ground attack roles with no changes to the onboard equipment.

There were three other features built in from the start of this design which were unusual for aircraft of the day. An arrestor hook was mounted under the rear fuselage to allow engagement with Runway Hydraulic Arrestor Gear (RHAG), to stop the aircraft in icy conditions or in the case of a brake failure. The fighter also had a 15ft (4.6m) brake chute at the rear base of the fin to shorten the landing roll where needed. The fuel system was designed from the outset to incorporate an air-to-air refuelling probe when required, the probe being available in a kit that could be mounted or dismounted as the operational needs of the customer dictated. Lastly, the fuselage structure had built in hard points to mount jet assisted take off equipment, as it was envisaged that some customers may wish to operate the aircraft from short or unprepared dispersed airstrips in time of war, the already strong undercarriage was built from the outset to withstand this kind of use.

What the design team created was an incredibly flexible, adaptable, strong, easy to maintain and yet still high performance fighter that would be cheap to operate in numbers, a remarkable achievement by any standards.

Before continuing with the development story that led to the world famous fighter, it is worth noting that an additional study was going on at the same time as this design work. A version of the design was laid out with a larger wing and more internal fuel, along with a fully capable arrestor gear and still further strengthened undercarriage. These were the last attempts Northrop made to introduce a navalised version of the fighter, which was offered to the US and Australian navies in two different formats.

At the beginning of 1958 the USAF and the Department of Defence (DoD) were shown the modified engineering mockup of the N-156F in its final form. This resulted in an order for three prototypes and a static test airframe on February 25 1958, the funding coming from the FX programme, a USAF project that supported the Military Assistance



Northrop N-156F, 59-4987, first prototype, seen here carrying 18 250lb bombs, an unlikely load as the wing pylons were initially only able to carry 1000lb of ordnance. **USAF**

Northrop N-156F, 59-4987, first prototype, in interceptor mode, with a pair of AIM-9 wingtip mounted Sidewinder missiles. **USAF**

Northrop F-5B, 63-8438, was the first F-5B produced. **USAF**

The eighth F-5B, 63-8445, became Northrop's company demonstrator and toured the world. Note the flags of the countries visited on the nose under the cockpit. **USAF**

The first customer to receive the F-5A and F-5B was the Imperial Iranian Air Force in February 1965. **Luigino Caliaro**

An early Northrop F-5A, 63-8372 was also used for unprepared field trials, seen here with a pair of 500lb bombs and wing tip tanks with their distinctive 'waisted' shape. **USAF**

Programme (MAP), a US Government initiative begun in 1949 aimed at providing military equipment to friendly nations to contain the perceived threat of Soviet expansionism. The choices of MAP equipment were regulated by the DoD's International Security Affairs Agency (ISAA), who supported the aircraft as the ideal choice for supplying to friendly nations. Northrop quickly began construction of the prototypes, a task aided by the existing factory tooling that was already producing the first T-38s.

While this was going on, Northrop also began discussions with a number of countries regarding the licence production of the fighter, including Australia, Belgium, the Netherlands, Italy and the UK. Ultimately, these discussions came to naught, but the fighter was to be built in Canada, the Republic of Korea, Spain, Switzerland and Taiwan. The first prototype, 59-4987, had to be fitted with the same J85-1 engines as the first T-38s because the afterburning versions were not ready. Despite this, on July 30, 1959, only four months after the first T-38 flew, Northrop's chief engineering test pilot Lew Nelson made the first flight. The performance of the single seater, even with the low powered engines, was astounding, easily breaking Mach 1 on this first 50 minute flight and, according to Nelson; "performing like a well educated lady" throughout the test.

The second aircraft, 59-4988, joined the test programme and was used for field maintenance and rough strip performance trials. These were carried out at Pensacola, Florida, in June 1961 and included landing in 1300ft (396m) on grass and taking off with a maximum fuel load from the same surface in less than 2500ft (762m). At this point, the USAF was supporting a simplified version of the F-104 Starfighter for the MAP programme and not the N-156F, which caused Northrop to slow the programme down as the company had been funding the development entirely on its own prior to the order for the three prototypes. However, the US Army's interest had been aroused by the rough field trials, as it was looking for a new close support fixed wing aircraft. Comparative trials between the second N-156F prototype, the Fiat G.91 and the Douglas A-4D-2N Skyhawk were held at Edwards Air Force Base for two months from January 1962. The army report clearly favoured the N-156F for its ruggedness, in-the-field maintainability and reliability. It was also noted that the small size of the aircraft and its small air intakes made it less likely to suffer damage from ground fire during ground attack missions. However, the USAF would not agree to the army operating its own fixed wing aircraft, a position supported by the DoD, so the army was to develop helicopters as its own support aircraft and the project was dropped.

At this point, it seemed to many at Northrop that the single seat version of the aircraft was dead, when the Kennedy administration decided a new, low cost export fighter was required for the MAP. The ISAA of the DoD informed Northrop that the N-156F was the victor of the resurrected FX programme on April 25, 1962, then on August 9 gave it the official designation F-5 and the official name of Freedom Fighter. The only changes required to the prototypes to fully conform with the FX specification was to fit the cannon armament and increase the external weapons load by fitting four wing pylons instead of two, which required local strengthening of the wing. Lastly, an additional fuel tank was fitted in the nose bay.

The third prototype, 59-4989, became the YF-5A and flew for the first time on July 31, 1963. This really kick started the F-5 programme, with 71 aircraft being ordered on October 22, followed by a second order for 99 more as the MAP funding to the USAF was increased to $83 million. Such was the sudden urgency behind the fighter requirement, the first production Northrop F-5A, 63-8637, made its first flight in October 1963.

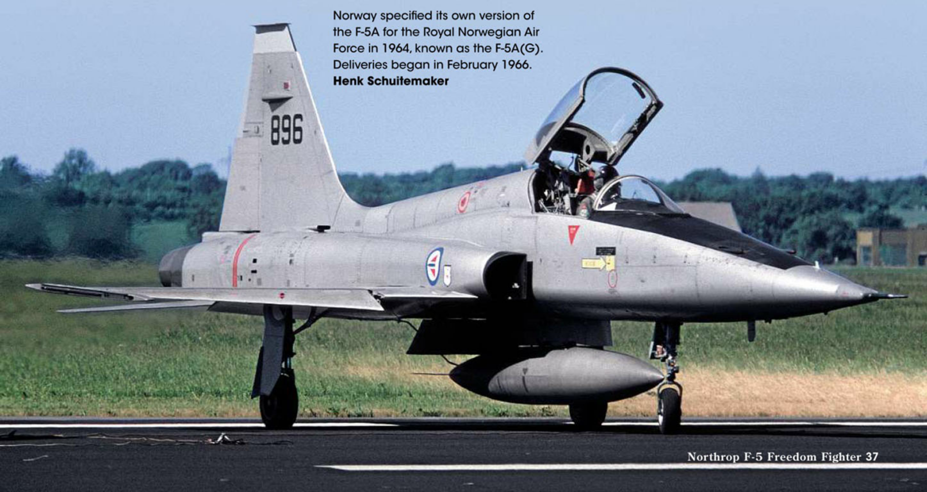
At the same time as this huge increase in activity, a two seat version of the fighter was initiated, known as the F-5B. It had been decided that a trainer version of the full weight fighter airframe would be a far better platform to introduce trainees to the handling of the fighter than the much lighter T-38. The T-38's take off weight was 11,700lb (5307kg), compared to the 20,100lb (9117kg) of the F-5A. The F-5B also retained the operational capabilities of the single seat F-5A, albeit without the cannon armament, enabling it to fill a dual role as trainer and strike aircraft. The nose was stretched to accommodate the second seat, deleting the cannons, and the air intakes were slightly modified to feed the new J85-GE-15 engines which now produced 4080lb (1850kg) thrust with afterburner.

Given the company's experience with the T-38 programme, now in full production, the first F-5B, 63-8438, made its first flight on February 24, 1964. Interestingly, after thorough flight testing, the F-5B was accepted and declared operational by the USAF on April 30, some four months before the single seat F-5A. The 4441st Combat Crew Training Squadron of the Tactical Air Command, based at Williams Air Force Base near Phoenix, Arizona, was the first USAF unit to be equipped with the F-5B on that date, and was to be responsible for training the aircrew of MAP supplied countries on the F-5. In February, Norway, followed later by Iran and Korea, had announced its selection of the F-5 as its new fighter. The first contingent of pilots, made up of Iranian and Korean pilots beginning training with the 4441st in April as the F-5B was declared operational.

The eighth F-5B of the production line, 63-8445, became Northrop's company demonstrator, making a tour of European and Middle Eastern countries between June and September 1964. The success of this tour, combined with the excellent handling of the aircraft and its systems, meant that the first customer for the F-5A and F-5B was the Imperial Iranian Air Force. The IIAF received its first 11 F-5As and two F-5Bs on February 1, 1965, at Mehrabad Air Base and would eventually acquire 107 of the first generation models of the F-5. The performance of the aircraft, along with its low initial and operating costs quickly attracted customers from all over the world, as will be related later in this issue. Altogether, Northrop built 624 F-5As, including the three prototypes, and 134 F-5B two seat operational trainers before production switched to the F-5E and F in 1972. There were also 89 of a third variant of the early airframe built, the RF-5A reconnaissance platform, but these will be covered later in this issue.

This large scale success came about from the application of sound, simple engineering practices in the airframe from the first design drawings. By keeping all of the costs as low as possible, and by making it possible to maintain the aircraft with basic tools and little equipment, Northrop created a fighter that countries could not only afford to buy, but afford to operate. The strength built into the airframe from the beginning meant that it would also remain serviceable for a long time under service conditions. It is no surprise to learn that several countries still operate the first generation of F-5s, often modified with new avionics and having undergone some degree of airframe refurbishment it is true, but the fact remains that the 49-year-old fighter is still perfectly capable of operating in a modern combat environment, an incredible achievement and a real credit to the men and women who designed and built them. ■

Words: Tim Callaway



Norway specified its own version of the F-5A for the Royal Norwegian Air Force in 1964, known as the F-5A(G). Deliveries began in February 1966.
Henk Schuitemaker

Skoshi Tiger

Captain Gil Dunne of the 10th Fighter Commando Squadron drops a pair of BLU-18 napalm canisters during an interdiction mission from Bien Hoa in South Vietnam in 1967. The aircraft, also carrying a pair of M-117 750lb general purpose bombs, is Northrop F-5A Freedom Fighter 64-13332, one of 12 of the type allocated to a combat trial known as 'Skoshi Tiger'. The aircraft flew hundreds of missions over Vietnam and were modified with refuelling probes for the trial, resulting in their redesignation as F-5Cs.

Skoshi Tigers & Commandos

The F-5's extended combat experience in Vietnam

A 10th Fighter Commando Squadron F-5 loaded with 500lb bombs and centreline fuel tank heads for an FAC that has pinpointed some targets north of the DMZ. **Gil Dunne via Warren Thompson**

Two famed aviation historians explain the use of the F-5 during the Vietnam War, and how it began the career of the aircraft with so many air forces worldwide.

F-5A 64-13332 at Bien Hoa AB, loaded with Mk 82 bombs and napalm tanks. **Dave Menard**

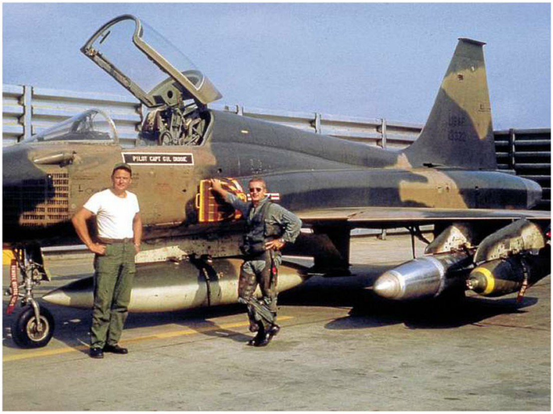
PROJECT SKOSHI TIGER BY DAVE MENARD

In the late 1950s, Northrop developed a lightweight twin-engine supersonic fighter that became known as the F-5 Freedom Fighter. Its first flight was logged on July 30, 1959, and the company had great expectations for marketing it worldwide among countries that were friendly to the United States. But early on it hit a brick wall in its efforts because the prospective buyers all asked why they should buy it when the USAF had not committed to bringing it into its inventory. This problem was solved by Project Skoshi Tiger when Colonel Frank Emory organized a provisional squadron (the 4503rd Tactical Fighter Squadron) to take the F-5 into the Vietnam War. It was a great success and it opened the door for Northrop to build more than 2200 airframes that would be flown by a multitude of air forces.

The F-5 went to war with the formation of the 4503rd Tactical Fighter Squadron (TFS). The 4503rd was activated at Williams AFB in Arizona, now closed, and arrived at Bien Hoa Air Base (AB) in early October 1965. I was at Bien Hoa in late 1965 as a member of the 3rd Tactical Fighter Wing (TFW) flying the North American F-100 Super Sabre (known as the Hun). The 3rd TFW arrived in early November 1965 and the 4503rd's maintenance troops used our shops, so I got to know many of them. The F-5s could carry the same underwing load as our Huns, but not as far. Also, they only carried two 20mm cannon versus a Hun's four, but the pilots liked them and they hacked it just fine. They had 12 aircraft assigned to the squadron, which were: 63-8424, 8425, 8426, 8428 and 8429, 64-13314, 13315, 13316, 13317, 13318, 13319 and 13332.

Although other sources have quoted different serial numbers, this is the definitive list. The 12 aircraft were redesignated as F-5Cs while they were at Bein Hoa, a fact recorded on the aircraft technical data blocks under the cockpits. Also, in April 1966, the unit number changed to the 10th Fighter (Commando) Squadron, since the four digit designation was a provisional one. The name of the project was in incorrect Japanese. The word 'skoshi' means 'little bit of' something, but most Americans who served in Japan used it for 'little' and that is how it was used in this instance. I recall remarking on this with one of the pilots who had also served in Japan and he agreed with me, but we both then agreed that

F-5A 64-13317, seen while in service with the 4503rd TFS at Bien Hoa, loaded with Mk.82 bombs and napalm tanks. **Dave Menard**



Captain Gil Dunne, a pilot in the 10th FCS, poses by his F-5 prior to flying a mission. He is loaded with M117 (750lb) and BLU-18 (napalm). This was taken at Bien Hoa in 1967. **Gil Dunne via Warren Thompson**

A 4503rd TFS F-5A, 63-8424, in a revetment at Bien Hoa AB, December 1965. **Dave Menard**

F-5A 64-13318 at Bien Hoa AB, facing both a natural metal and camouflaged F-100 of the 3 TFW. **Dave Menard**

F-5A 64-13332 went on to become part of the equipment of the 10th FCS and is seen here in the later markings. **USAF**

to change it was way, way above our pay grades. The correct word should have been 'chisai' but oh well.

Aside from the many ground attack and support missions the F-5s flew, and contrary to published reports, the unit did go out seeking air-to-air encounters with enemy aircraft. The squadron moved up to DaNang for a time, with the sole intention being to mix it up with MiGs. One of the driving forces behind this was one of the pilots, Colonel Wiltz P Segura, a Cajun from south of New Orleans. He was the vice-wing commander of the 3rd TFW, who took over the wing when the boss, Robert Ackerly, was away from the base. Col Segura had been officially credited with 4.5 air-to-air kills during the Second World War. He got checked out in the F-5 there at Bien Hoa, rather than back at Williams so he could maybe get another confirmed kill and thus become an 'ace' at long last. Sadly, it was not to be, as no MiGs were ever sighted. Oh well.

Several of the original Skoshi Tigers had long careers, particularly 64-13317 as illustrated by some of the images here. 317 was an original aircraft assigned to the 4503rd TFS from day one. After finishing its tour it was sent back to Northrop and completely taken apart to see the condition of the airframe after exposure to the tropical climate. The airframe was found to be sound, so 317 was put back together and sent to Williams AFB in Arizona in a training role. Later, it was flown up to McClellan AFB in California and pickled for overseas shipment, to be sent back to South East Asia, but here the trail goes cold and her fate is unknown.

The Skoshi Tiger programme proved the F-5 was a capable combat aircraft, and opened the door to further development of the aircraft and its eventual tremendous success in service around the world.

AFTER SKOSHI TIGER BY WARREN E THOMPSON

At the time that the Skoshi Tiger experiment ended on March 9, 1966, there was a high level meeting taking place in Honolulu regarding the need for more aircraft in the war. A decision was made by the commanding officer of 7th Air Force Lieutenant General Joseph H Moore to keep the Skoshi Tiger F-5s in Vietnam for another tour and they would be flown by the 10th Fighter Commando Squadron commanded by Lt Col Robert F Titus. The squadron would be under the control of the 14th Air Commando Wing. The announcement also stated that the number of F-5s would be expanded beyond the original 12. Most of this squadron's pilots were high-timers in various fighter types and their tour would underline the fact that the F-5 was an excellent close air support platform. The 10th FCS would officially take over operation at Bien Hoa on April 8, 1966. The meeting in Hawaii gave the green light to adding 10 more fighter squadrons flying various types in Vietnam and by the 10th taking over the F-5s, this delayed the South Vietnamese from receiving it though they desperately needed it.

The little Northrop fighter excelled in the close air support and interdiction roles. However, the missions calling for deep penetration into route packs 5 and 6 were reserved for the F-4 and F-105. The Freedom Fighter could not carry the payload that those two could. However, its main competitor in the lower route packs was the F-100 Super Sabre and it could easily hold its own in that arena. Lt Col James Porter compares the two aircraft. "When comparing our F-5s with the F-100, it could do everything that the Hun could do except match its loiter time over target. ➤

Payloads and take off distances were about the same. With the addition of the centreline tank on our fighter, the gap was closed quickly. Another modification, the nose jack, would place the attitude of the wings at a flyable angle of attack from the outset of the take off roll, cutting it by one half. If this had been done prior to the Skoshi Tiger involvement, it would have turned some heads."

In 1966, the influx of North Vietnamese troops and supplies into the south was beyond the ability of the Americans to control. The close-in fighter bombers, F-100, F-5 and AD Skyraiders, were working overtime and not making much headway. The rail system in Vietnam had never been much to brag about, so the enemy had to depend on crude trails, roads and waterways to shift supplies up to the front line. The F-5s, equipped with 20mm cannon, excelled in low altitude strafing with a fast exit. This became evident when the enemy began using Sampans to transport equipment and supplies down the numerous waterways. One of the pilots stated: "There was only one weapon of choice on this type of target and that was our cannon. The rockets that we sometimes carried proved to be so erratic that they were useless. If they had the slightest ding or dent in one of their fins they would go off in any direction except where they were aimed. I will say that when any target had a salvo of those 2.75in rockets fired at it, it probably scared it to death. However, we were very accurate with our 20mm and we did some serious damage to any target we fired on. We destroyed numerous Sampans with our guns and many were carrying ordnance or fuel which resulted in a massive explosion. These floating transports were very active at night."

One of the VNAF F-5s prepares to set up for a bomb run while working with an FAC just north of the DMZ. This was taken in early 1969. **Janeral Holley via Warren Thompson**

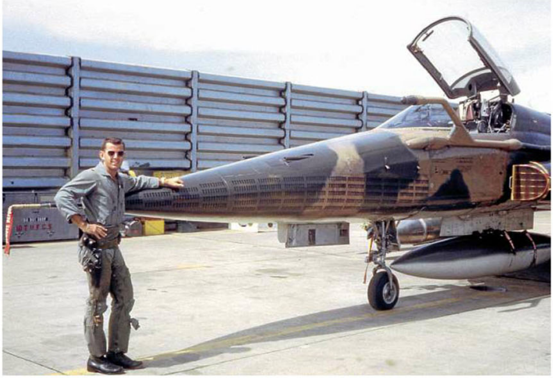
The North Vietnamese were very good at moving troops, supplies and equipment below the DMZ. This included digging intricate tunnels that could house hundreds of troops. When a FAC spotted a large number of enemy combatants moving on a trail, by the time that he could call in a strike, they had disappeared. This usually meant that they were hidden in a nearby tunnel. Captain Jim Martin, a pilot in the 10th FCS, comments on this type of situation and the most effective ordnance used to counter it: "We carried the M117 750lb bomb which was the heaviest ordnance we could carry and it was also the most destructive. When delivered accurately, it was lethal to troops hiding in those tunnels. It was markedly better than the 500lb bombs because the case was thinner and there was more blast/concussion. It could get down far enough to destroy a lot of underground bunkers and collapse numerous tunnels. The only area safe from its blast was to be far enough underground that it couldn't reach you."

This F-5B (two-seater) was flown by the VNAF out of Bien Hoa in May 1967. **Billy Gilbert via Warren Thompson**

One of the American pilots prepares to fly a mission against enemy troop movements after his F-5 had been loaded with napalm and GP bombs (Mk.82s). This was taken in the autumn of 1966 at Bien Hoa. **James Martin via Warren Thompson**

Before the Skoshi Tiger mission was completed, the word was already out to many of the foreign air forces that the F-5 was a great close air support platform that could be maintained with minimum downtime. The key to its success was the fact it was very fast and could carry a wide variety of ordnance that could be delivered with pinpoint accuracy. Captain Martin explains the CBU pod (LAU-3) and how it was used: "This was one of the more sophisticated pieces of ordnance, but it was not one of our favourites. The pod carried numerous small bomblets that would disperse out and cover a wide area. It had a devastating effect against ground troops that were concentrated in a small area. It would have been my second choice behind the M117. It consisted of two canisters. On delivery, the run-in had to be perfectly level at an altitude of between 600 and 800ft and a speed of about 450 knots (520mph). Wind drift was also a factor. All of these factors determined the dispersion and pattern. We usually made from one to three passes. After we unloaded the pods, we usually followed through with multiple strafing passes with our 20mm. The Skoshi guys started using the weapon and once the 10th FCS got in place, we used it in much greater numbers."

One of the secondary missions flown by the 10th was as an escort for the C-123 'Ranch Hands' that were spraying the Agent Orange defoliant along the various trails. For the sprayers, this was extremely dangerous due to the very low altitude they had to fly for effective results. At least two or three F-5s would fly right above them, loaded with ordnance and 20mm rounds. If the transports started taking ground fire, they could react quickly and remove the threat. Once the F-5s began escorting them, the resistance came to a quick halt.

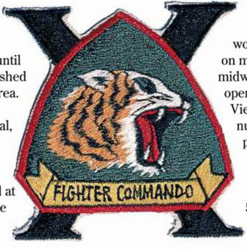


Captain James Martin poses by the 10th Squadron's high time F-5. Note the endless number of mission symbols painted on the nose. This was taken at Bien Hoa in January 1967. **James Martin via Warren Thompson**

Stacked tight in formation, one of the VNAF fighters pulls in close to take a picture of his wingman that had expended all of his ordnance on a strike against enemy troop positions. **Janeral Holley via Warren Thompson**

The South Vietnamese pilots loved to fly in very tight formation on returning from a mission. This is a good example of their skills in the cockpit. **Curtis Burns via Warren Thompson**

Captain Bill Rippy recalls one of those missions that had a lot of excitement: "Our job, after rendezvousing with the Ranch Hands, was to form an echelon formation with our three F-5s parallel to the C-123s and above and to the side of them at about 1000ft. In single file with about 1000ft separation between the F-5s, we would dive down to 200ft and pass diagonally in front of the sprayers at about 1000ft. As we passed over the projected flight paths of them, we would punch off a few cluster bomb units (CBUs) and then pull back up to our perch to start the next pass. This procedure was repeated until the Ranch Hands had finished spraying their assigned area. On this particular day, everything seemed normal, with good weather, clear visibility and a quick rendezvous. As flight leader, I called in, levelled at 200ft and proceeded to the point for the CBU drop. I pickled the first wave of bomblets off and immediately received a violent jolt. I pulled up, declared being hit and told my number two man to come up and look me over. Even before he got in close he could see fuel streaming from my fuselage and wing tank. The dreaded master caution light came on almost immediately which indicated I had a lot of major problems.



"I immediately declared an emergency and proceeded to the ordnance emergency drop zone to get rid of my CBUs. Fortunately, they jettisoned as they should have and I headed toward our base. For some forgotten reason, I had to fly wing the rest of the way, right down to touchdown. When I climbed out of the cockpit, I saw just how lucky I had been. When we finished counting, there were 99 holes in my F-5. Further investigation revealed that one of my cluster bomb units had armed and detonated on release. When I left Vietnam some four months later, that aircraft was still being repaired. During my entire tour in Vietnam, that was the closest I had come to being shot down and that was by my own ordnance. Fortunately, Northrop had built a very tough little fighter that could absorb a lot of punishment and still fight."

The F-5s did not have to worry about SAMs or MiGs on most of their missions but midway through the 10th's operations, the North Vietnamese brought in large numbers of Quad-50s which proved to be the most dangerous weapon they would face. On one mission involving three F-5s, the objective was a small village south of Bien Hoa that was housing numerous VC troops. What Intel didn't know was that the area was bracketed by Quad-50s. The first F-5 in was hosed down to the extent he immediately burst into flames near the rear of the fuselage. The pilot punched out and landed in the middle of a huge rice paddy that had just been fertilized with human waste. Moments later, two VNAF Skyraiders came in to assist in the rescue. Both of them were shot down and they landed in the middle of the same paddy. Two rescue helicopters were trailing behind and they were shot down attempting to pull off a rescue. Finally, two more helos arrived and the other two F-5s were able to knock out the gun emplacements allowing the downed airmen to be rescued. Five aircraft went down in total. One of the F-5 pilots went to a small friendly strip nearby and got his 20mm guns reloaded. He went back and caught a large number of enemy troops examining the wrecks. He attacked and killed many of them.

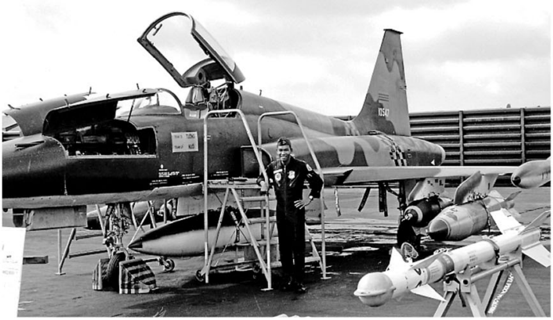
The productive F-5 operations by the 10th Fighter Commandos officially ended on April 17, 1967. The VNAF began its combat operations with the type on June 19. By this time, a large number of South Vietnamese pilots had become proficient in the Freedom Fighter as they had gained experience while flying missions with the 10th pilots. Most of these pilots had already gone through the basics earlier while training at Williams AFB Arizona. Records show that six months into the 10th ACS's tour (October 1966), it was announced that 33 officers from the VNAF had been selected to begin training at Williams. It was determined that all of the VNAF F-5 pilots training at Williams would have to have at least 55 hours' flying time in the aircraft before being considered for graduation.

Almost all of the American instructors at Williams were Skoshi Tiger veterans. Some of the 10th pilots remained at Bien Hoa to fly and instruct with the VNAF pilots and some of the ground/maintenance crews also stayed to help instruct the enlisted types. At this time, the South Vietnamese had been flying the A-1 Skyraider and A-37 for some time and they were anxious to bring the F-5 into inventory. The first VNAF squadron to receive the speedy little fighter was the 522nd. Records from that squadron state that all of the pilots in that unit ➤

STATISTICS FOR THE 10TH FIGHTER COMMANDO SQUADRON (F-5 ERA) IN VIETNAM

Dates: April 8, 1966, to April 17, 1967

Total combat sorties	7321
Total combat hours	7537
Aborts	85
Battle damaged F-5s	17
Aircraft losses	8
Ordnance expended:	
Napalm	9777
CBU	875
GP Bombs	11,589
20mm Rounds	778,566


One of the South Vietnamese pilots proudly shows off his F-5 that has been loaded with M117s and finned napalm. Some of the other types of ordnance they carry are on display in the same revetment. **Dexter Martin via Warren Thompson**

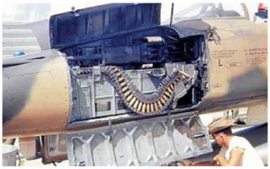
were high-timers in the A-1 Skyraider, so their level of combat experience was outstanding. In a press release dated September 27, 1966 (six months after the 522nd received its F-5s), it was confirmed that the VNAF was to receive another 20 F-5s to form up another full squadron. This put its air force inventory past 400 aircraft, most of which were A-1s. As a side note, in the fiscal year 1966, there would be about 240 South Vietnamese pilots trained in the US to fly fighter bombers, twin engine transports and helicopters.

During the 10th ACS period and the VNAF F-5s, there were a few occasions where the F-5s flew MiG Caps, but they did not encounter any. On these missions, they were each armed with two Sidewinder missiles. The 50 gallon wingtip tanks had to be removed to achieve this configuration. One of the pilots that did fly the MiG CAP, Captain Bob Terbet, states: "I believe if we had had the opportunity to tangle with a MiG-21, we would have come out pretty good as long as we could have held them down to the lower altitudes. I have always strongly believed that the pilot usually determines the outcome and our guys were very good." The speed and dogfighting abilities of the F-5 have survived many decades as it is still used as an aggressor aircraft against some of the more recent fighters such as the F-15, F/A-18 and F-16.

From the time that the Skoshi Tiger experiment got in place through the VNAF era, the F-5 in-service rate continued to baffle the experts. Although most of the missions were short, the average sortie rate per day was between 1.4 and 2.0. During the peak months, records state that each of the aircraft was averaging about 50 hours per month. Lt Col Robert F Titus, commanding officer of the 10th FCS, comments on the Freedom Fighter: "The F-5 was an exceptionally good weapons delivery platform. The training squadron at Williams AFB consistently beat the Luke AFB guys in gunnery scores and those high scores carried over into Vietnam. We could put our bombs on target and all the FACs knew it. One night the Mike Force (ground troops) guys came over to our squadron bar to buy a round of drinks for saving them during a attack by the NV regulars. We were fortunate to get down through a heavy overcast, but with some good luck, we got down below it and put a lot of napalm right on top of the enemy. I hated to leave the F-5, but I really wanted to fly the F-4 into the higher route packs."

There is no doubt that the evaluation of the F-5s in Vietnam was one of the most successful marketing tools in the history of aviation. In 1996, there were still 1600 Freedom Fighters remaining in service with 25 air forces worldwide. Almost 500 of these were the early F-5A models. The upgrades continue and the end is not in sight. ■

Words: Dave Menard and Warren Thompson


The most formidable weapon the quick F-5s had was their 20mm cannon. They were very effective in low level strafing. This was taken on the 10th FCS ramp at Bien Hoa in August 1967. **Bob Titus via Warren Thompson**

An Ordnance crew loads napalm on an F-5 at Bien Hoa. It was a favoured weapon when going up against troop concentrations and supply dumps. **USAF via Warren Thompson**

South Vietnamese Prime Minister Nguyen Cao Ky (left centre) conducts a meeting with some of his squadron leaders and USAF advisors. Ky had been commanding officer of the VNAF forces between 1963 and 1965. This was probably taken in late 1967. He was an accomplished fighter pilot. **Billy Gilbert via Warren Thompson**

This is a rare image of a Thai Air Force F-5 on the ramp at Don Muang Airport in Bangkok. **Bill McDonald via Warren Thompson**

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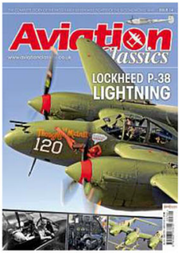

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TIGER TAKE OFF

A pair of Northrop F-5A Freedom Fighters of the 522nd Fighter Squadron of the Republic of Vietnam Air Force (VNAF), take off from Bien Hoa Air Base on a close air support mission in early March 1971. Loaded with modified finned napalm tanks and ML-117 750lb general purpose bombs, the aircraft are wearing the distinctive black and yellow checkerboards of the 23rd Tactical Wing.

One of the first group of customers for the RF-5A was the Turkish Air Force. Three of its aircraft are seen here, with different nose windows open or opaque. **Luigino Caliaro**

Tigereyes & Tigergazers

The photoreconnaissance F-5s

As the N-156F project was being defined, an offshoot was also proposed, the N-156C. This was to be the first photoreconnaissance version of the aircraft which was to eventually be used by nearly every F-5 customer, from purpose built factory examples to aircraft modified from existing fighter versions.

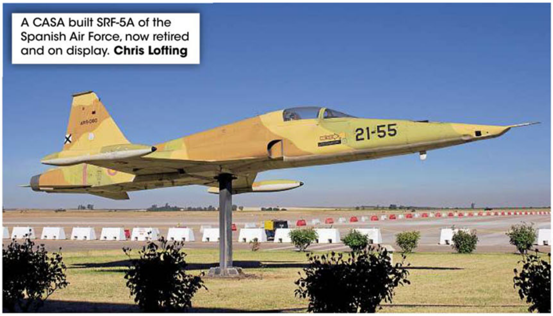
With the T-38 in production, as has already been related, work continued on the F-156F single seat fighter and its two seat derivative. As part of this work, Welko Gasich and Lee Begin added another variant to the concept, known as the N-156C. This was drawn from the single seat designs, but included a nose section that could be rapidly changed from the standard fighter nose to one containing windows and fittings for cameras. This was the first photoreconnaissance version of the aircraft and had been proposed after the management and technical team from Northrop had toured the world in 1954 to determine potential customer needs for the aircraft. One of these requirements had been a reconnaissance capability, either as an integral part of the aircraft or as a camera pod solution.

The fighter version was seen as an ideal platform for this role, as again its small size would enable it to perform low level sorties without defences being aware of it until it had already taken its pictures and gone, something not possible with a larger airframe. The first orders for a purpose built reconnaissance aircraft, known as the RF-5A, were received from Iran and Norway in 1967, but due to the pressure on the production lines to produce the T-38, F-5A and F-5B, the first RF-5A did not make its first flight until May 1968. James Ford was the USAF project engineer for the system test of the nose mounted cameras which took place at Edwards Air Force Base in California beginning in June 1968. Majors Cecil Powell and Hubert Thornber were tasked with flying a wide variety of mission profiles against specific targets; landmarks on the California coast and trails in the High Sierra mountains were among the targets they were sent to photograph to thoroughly test the performance and ease of operation of the cameras.

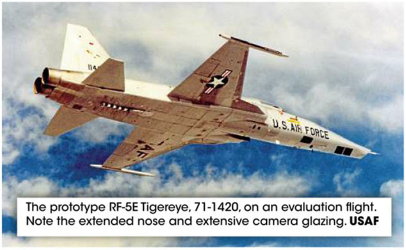
The RF-5A was fitted with a longer nose featuring an angled front window for a forward looking camera. The underside and sides of the nose were fitted with windows through which the oblique cameras looked. The entire upper and front section of the nose was hinged, swinging upwards and forwards, rather like the bonnet on a Triumph Spitfire, to allow ease of access to the cameras and film magazines. Inside the nose, four KS-92 cameras were mounted, each equipped with an individual light sensor making them capable of automatic exposure.

The cameras, fed by individual 100ft (30.4m) film magazines mounted above them, were arranged to give forward oblique, trimetrogon and split vertical coverage, all on a single pass of the target. Each could be fitted with lenses of different focal lengths, giving a total of six different basic camera configurations. A trained crew could remove, reload and replace all four cameras in under five minutes, such was the ease of access.

Other than the sharply raked 'chisel' nose and the camera windows, there was little to distinguish the RF-5A from the F-5A fighter. Even with the cameras fitted, the cannon armament in the nose was retained, giving the



A CASA built SRF-5A of the Spanish Air Force, now retired and on display. **Chris Lofting**

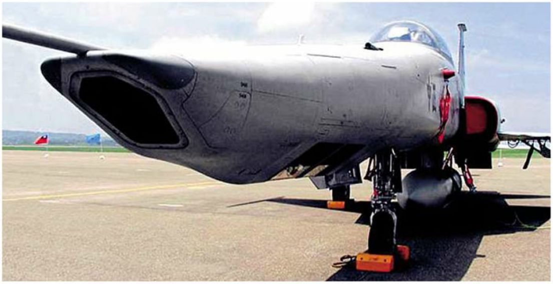

The prototype RF-5E Tigereye, 71-1420, on an evaluation flight. Note the extended nose and extensive camera glazing. **USAF**

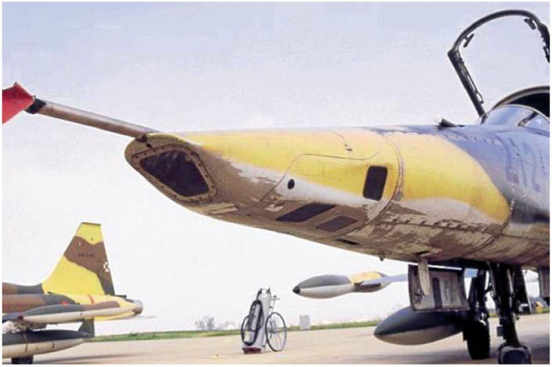
Northrop RF-5A of the Royal Norwegian Air Force. **RNAF**

type only a slightly reduced combat capability due to the weight of the cameras. As already mentioned, part of the N-156C design specification that led to the RF-5A was that the camera nose could be removed and replaced quickly. In practice, this never happened as the task was deemed unnecessary, the aircraft could still operate in the fighter or fighter bomber role regardless of the nose. Altogether 89 RF-5As were built, deliveries beginning in late 1968 to the Imperial Iranian Air Force, followed by the air forces of Greece, Morocco, Norway, the Republic of Korea, South Vietnam, Thailand and Turkey.

When the second generation of the F-5 was introduced, the F-5E and F, Northrop again developed a photoreconnaissance version as a private venture. Known as the RF-5E Tigereye, unlike the earlier RF-5A this was a truly dedicated reconnaissance platform. Initially, Northrop had only intended providing the F-5E reconnaissance variant with a detachable mission nose, similar to that of the RF-5A, but upgraded to carry four of the new and much more capable KS-121A cameras. This nose was supplied as a kit to Saudi Arabia and fitted to several Royal Saudi Air Force F-5Es, but the conversion proved to be no small task, requiring over 100 man hours to fit and even longer to remove, hardly a quick change modification.

By the 1970s, given the addition of upgraded radars and other avionics, all competing for space in the increasingly packed nose of the F-5E, Northrop decided that a complete redesign was the only way forward to provide a state of the art reconnaissance capability to F-5E customers. This would also enable the RF-5E to compete with the capabilities of the McDonnell Douglas RF-4E Phantom, but with a much smaller and cheaper to operate airframe. The design called for the F-5E nose to be stretched by 10in (25cm) providing a volume of 26cu ft (0.73cu m), nine times the amount of space available in the nose of the RF-5A. The first aircraft to be converted was F-5E 71-1420, which had been leased back from the USAF for this purpose. As with the earlier version, the front of the nose was fitted with an angled window that gave it that ‘chisel’ look, but here the similarities end. Behind this, the nose was deepened with four angled windows facing outwards in a vee shape, not unlike an inverted glass cloche. A single KS-87B camera was mounted in the extreme nose position,


A close up of the STAero modified nose of a ROCAF RF-5E Tigergazer. **Kim L Seung**


A close-up of the nose and camera windows of a Spanish Air Force RF-5A. **Lucio Alfieri**

One of the seven RF-5E Tigergazers modified by STAero for the ROCAF. **Kim L Seung**

A Republic of Korea Air Force RF-5A with the camera nose in black. **USAF**

One of the 10 RF-5E Tigereyes of the Royal Saudi Air Force. **RSAF**

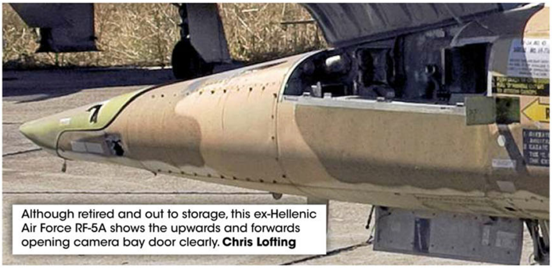
with four of the KS-121As mounted behind it looking downwards and outwards.

While it was entirely possible to retrofit the Tigereye nose onto existing F-5Es, the added weight required the strengthening of several fuselage keel structural members, so was not really a cost effective solution. The only Tigereyes sold were those manufactured from the outset as such. The deeper redesigned nose did allow a single 20mm cannon to be retained however, maintaining the RF-5E's dual role capability. In this form, 71-1420 took to the air for the first time at Edwards Air Force Base on January 29, 1979, flown by Darrell Cornell.

The reconnaissance system was thoroughly tested before the aircraft was converted back into a standard F-5E configuration and sold to Brazil. Given the encouraging results of the trial, Northrop expected a potential market of similar size to that for the RF-5A, but the cost of each purpose built RF-5E, being half as much again as a standard F-5E, proved to be its undoing. The first customer was Malaysia, which ordered two in September 1980, followed by Saudi Arabia which purchased 10 more. But that was all there was to be; only these 12 RF-5Es were ever built by Northrop.

These were not the only F-5Es to become reconnaissance aircraft however. In 1994, Singapore Technologies Aerospace (STAero) converted eight F-5Es into RF-5Es for the Singapore Air Force. This was followed by the conversion of seven low hour Republic of China (Taiwan) Air Force (ROCAF) F-5Es into a similar configuration. The nose of these aircraft was stretched by 8in (20.3cm) with six windows added to the front, sides and underside. The AN/APQ-159 radar was removed, as was one of the M-39 cannons, to make room for the cameras, and ballast was added between the engine exhaust pipes to balance the weight of the new nose. KA-95, KA-87, RS710 and Type 900 cameras could be fitted in a variety of combinations to provide full photographic coverage. In this form, the aircraft was named the RF-5E Tigergazer, the first being delivered in August 1997. The new aircraft replaced the RF-104G in ROCAF service, which was retired in 1998, all seven RF-5Es being allocated to the 4th Tactical Reconnaissance Squadron based at Taoyan, where several of them are still in service today.

Without doubt the rarest of the F-5 models, the photoreconnaissance variants remain valuable assets in several countries and are destined to remain so for the foreseeable future. ■ *Words: Tim Callaway*



Although retired and out to storage, this ex-Hellenic Air Force RF-5A shows the upwards and forwards opening camera bay door clearly. **Chris Lofting**

One of the two RF-5E Tigereyes purchased by the first customer for the type, the Malaysian Air Force. **USAF**

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THE SAINTS

Low and fast, a pair of Aggressor Northrop F-5E Tiger IIs of the US Navy's VFC-13 'The Saints' prepare another training ambush from deep in the Stillwater Mountains near their home base of Naval Air Station Fallon in Nevada.

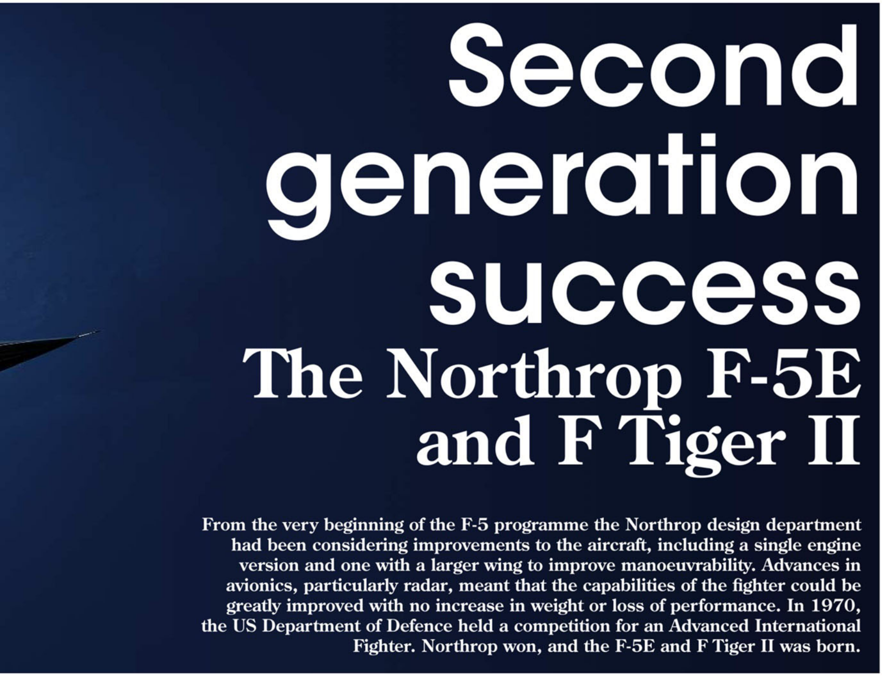
A pair of F-5Ns of VFC-111, The Sundowners, over the Florida coastline. **Jos M Ramos - RamosAviationPhotos.com**

The data available to Northrop from the service use of the F-5A and B led them to a number of conclusions to improve the aircraft. The first centred around the need for a better radar, as the systems developed in the years since the aircraft first flew were now much smaller and lighter, with far greater range. The manoeuvrability of the aircraft needed improvement too, which led to a team of engineers reassessing the wing and its structure. At the same time, the initially troublesome J85 engine development had resulted in a reliable and fuel efficient engine with a tremendous power to weight ratio, further improved in 1963 with the introduction of the J85-GE-21 with its larger compressor and output of 5000lb (2268kg) of thrust with afterburner.

The sixth production F-5B was leased to General Electric for engine testbed development for the new version of the J85, the work carried out under the direction of Virgil Weaver. This required redesigning and expanding the engine bays and enlarging the air intakes to provide the greater airflow the more powerful jet needed. At the same time, a team of Northrop engineers went to work on the wings, extending and expanding the span and leading edge root extensions (LERX) to increase the wing area and hence the lift and manoeuvrability of the new aircraft. A plug was inserted between the wing halves under the fuselage which increased the wingspan to 26ft 8in (8.12m) with the wingtip missile rails and increased the wing area by 16.2sq ft (1.5m). All of this resulted in an increase of 38% in the maximum lift the wing provided. The modified aircraft, designated YF-5B-21, flew for the first time on March 28, 1969, nearly 10 years after the original N-156F, General Electric test pilot John Fritz taking 68-8445 on this 40 minute trouble free flight.

The modified aircraft had a number of other new features aside from the engines. In order to provide an increased airflow and cool the larger plenum chamber of the new J85, louvered doors were fitted on either side of the rear fuselage between the wings and tailplane. The nosewheel leg was substituted for that developed for the Canadian CF-5, being a two position unit. For landing and taxiing, the leg remained in its traditional position. For take off, it could be extended by 13in, (33cm) to raise the nose by three degrees. This shortened the take off run by

IAI and Sogerma of France upgraded the F-5Es and Fs of the Moroccan Air Force. **USAF**



Second generation success

The Northrop F-5E and F Tiger II

From the very beginning of the F-5 programme the Northrop design department had been considering improvements to the aircraft, including a single engine version and one with a larger wing to improve manoeuvrability. Advances in avionics, particularly radar, meant that the capabilities of the fighter could be greatly improved with no increase in weight or loss of performance. In 1970, the US Department of Defence held a competition for an Advanced International Fighter. Northrop won, and the F-5E and F Tiger II was born.

anywhere between 10 and 20%, depending on the load the aircraft was carrying and the atmospheric conditions of the day.

This was one of the improvements customers had requested for the aircraft based on experience of operating the F-5A with high loads on hot days as the take off run could be prodigious. These improvements to the design did not impact on its main selling points of simplicity and maintainability, something the Department of Defence (DoD) was keen to avoid, since the cost effectiveness and affordability of the F-5 had been the major advantages highlighted in recommending the aircraft for supply to friendly countries via the Military Assistance Programme (MAP).

On February 26, 1970, the DoD announced a competition for an Advanced International Fighter to which Northrop, McDonnell Douglas, Lockheed and Ling Temco Vought replied, all with modified versions of existing designs, the F-5, F-4E Phantom, F-104 Starfighter and F-8 Crusader respectively.

After six months of comparative analysis of the four bids, the DoD announced Northrop to be the winner. The first production contract was issued on December 8, 1970, and included five pre-production test and development aircraft and 325 production aircraft, which from January 1971 were given the designation of F-5E.

Embraer and Elbit upgraded the Brazilian Air Force F-5Es to produce the F-5EM. **Chris Lofting**

The new nine stage compressor in the J85-GE-21 required that the fuselage be 15in (38cm) longer and 16in (40.6cm) wider than the F-5A, the enlarged fixed intakes being supplemented by the rear fuselage intake doors for take off and low speed operations. However, the first of the pre-production aircraft were delayed by the need to develop titanium engine exhaust shrouds to cope with the increased temperatures the new engine produced. In order that this did not cause further delays to the flight test programme, the USAF changed the requirement to six pre-production models in November 1971.

On August 11, 1972, Hank Choteau made the first 50 minute flight in F-5E 71-1417 at Edwards Air Force Base. Seven days later, flight testing began but ran into trouble in September as modifications to the engines were required, which in turn required more static testing to be performed. These delays meant that the first F-5E was not accepted by the USAF until April 25, 1973.

The trials continued, testing not only the airframe and engines, but the new systems fitted to this much improved machine. The first and most important of these was the ➤

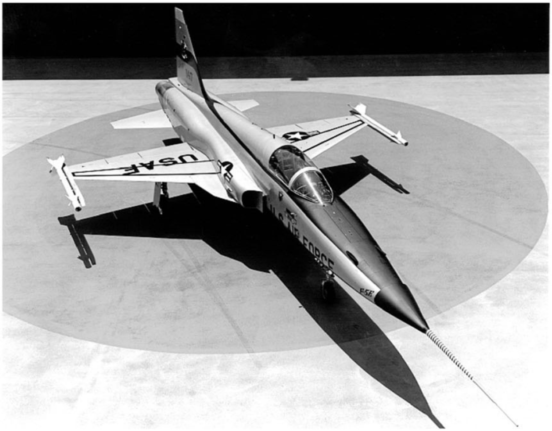
addition of a radar, since neither the F-5A nor B was fitted with one. The F-5E had an Emerson AN/APG-153 I-band pulse-doppler radar which had been specifically developed to fit into the small nose section of the F-5. It had four modes, two air-to-air target search modes at different ranges, a dogfight ranging and gun cueing mode which locked on to the closest target, and a missile cueing mode for use with the AIM-9 Sidewinder.

This data was fed to the pilot via a General Electric ASG-29 gyro gunsight and a small 5in radar display in the cockpit. Both of these systems were upgraded during the service life of the F-5E, the radar being changed to the Emerson AN/APQ-159, with an extended range of 20 nautical miles (37km) and a new planar phased array antenna and improved reliability; the gunsight was changed to the General Electric ASG-31 lead computing sight. Also tested on the F-5E was the Laser Augmented Target Acquisition and Recognition System (LATAR). This was mounted under the forward fuselage and included a laser target designator, point tracker and electro-optical sensor and was again a response to customer needs for an improved air-to-ground capability.

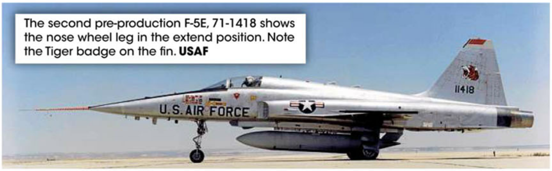
Aside from standard UHF radios, direction finding and IFF, the F-5E could also be fitted with an inertial navigation system (INS), TACAN, electronic counter measures and chaff and flare dispensers, depending on the customer's individual requirements. One very useful side effect of the rear fuselage redesign to accommodate the new engines was that the internal fuel capacity increased from 585 to 671 US gallons (2214 to 2540 litres). The first unit equipped with the F-5E was the 425th Tactical Fighter Training Squadron (TFTS) at Williams Air Force Base, who again were to be responsible for the majority of the training of customer nation air and ground crew. They were to use the aircraft until June 1989, during which time their training courses had graduated 1499 students from around the world.

While these trials were going on, Northrop began a similar upgrade to the F-5B two seat design, intending to produce an equally combat capable trainer. This requirement stemmed from the performance and capability differences between the F-5A and F-5E, since the older F-5B would no longer be able to operate as an effective trainer for the new version of the fighter in the opinion of many customers. The modification of the F-5E to produce the F-5F was exactly as that between the F-5A and B, the fuselage was stretched and the second seat added, the rear cockpit having all the equipment of the front except for the gunsight. A radar was included in the nose, the smaller Emerson AN/APQ-157, a derivative of the -153 model fitted to the F-5E with similar capabilities.

The compact size of this radar enabled one M-39 20mm cannon to be retained on the port side of the nose, making the F-5F fully capable as a weapons trainer or as a combat aircraft. This additional weight so far forward necessitated the addition of ballast to the rear fuselage to keep the aircraft in balance. The prototype F-5F, 73-889, was flown for the first

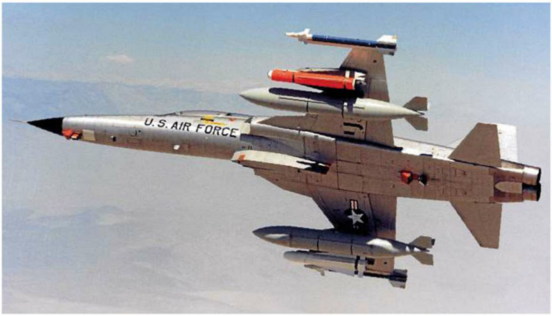


The first pre-production F-5E, 71-1417, showing the enlarged leading edge root extensions. **USAF**



The second pre-production F-5E, 71-1418 shows the nose wheel leg in the extend position. Note the Tiger badge on the fin. **USAF**

The prototype F-5F, 73-889, a remarkably elegant aircraft. **USAF**



The prototype F-5F, 73-889 with a load of drop tanks, Maverick and Sidewinder missiles. The orange box under the nose is a camera to record the weapons releases. **USAF**

The F-5E proved very reliable, as evinced by this special scheme to celebrate 30 years of service of the F-5E Tiger II in the Brazilian Air Force. **Luiz Carlos Padilha**

time at Edwards Air Force Base by Northrop test plot Dick Thomas on September 25, 1974. The second aircraft, 73-890, flew the same day and both joined the test and trials programme. By this time, the aircraft had also acquired a new name, Freedom Fighter being dropped in favour of Tiger II, the 'II' being to prevent confusion with the Grumman F-11 Tiger, although the last of these aircraft had been retired in 1969.

The F-5E and F quickly began replacing the earlier models of the aircraft in service with a number of countries, the first of these being Iran in February 1974 when the Imperial Iranian Air Force received its first F-5Es. Eighteen F-5Es of a later order for Iran were diverted to South Vietnam to help bolster the Vietnam Air Force (VNAF), who were already operating the F-5A. Altogether 55 F-5Es were supplied, but the lack of ground crew trained in the more complex systems of this aircraft limited their combat role in the closing years of the war. The surrender on April 30, 1975, meant that the F-5s that had not escaped to Thailand were captured and later pressed into service by the Vietnam People's Air Force (VPAF). It is believed that 87 F-5A and Bs and 27 F-5Es were captured, the aircraft being used during the invasion of Cambodia in 1979 and against China in a border clashes prompted by the Vietnamese invasion. The fact these aircraft could operate for many years without spares and only basic engineering support is testament to the rugged reliability of the aircraft.

As the capabilities of the new aircraft were demonstrated, orders came in from all over the world, not just from existing F-5A customers. Countries such as Brazil, Kenya and Malaysia all joined the impressive list of 37 nations worldwide that were to operate the type. Production of the Tiger II was to exceed the already impressive numbers of the Freedom Fighter models, with 793 F-5Es and 146 F-5Fs being built, along with 12 RF-5E Tigereye reconnaissance aircraft as already described. These numbers were boosted still further by licence production in Switzerland, the Republic of Korea and Taiwan, as is detailed elsewhere in this issue. The final delivery of an F-5 from Northrop took place in 1989, but that was not to be the end of the development story.

Northrop Grumman, as it now is, still offers new parts and maintenance, as well as structural and equipment upgrades for the F-5 series of aircraft, as these are still widely used by many countries. It developed the LN-260 INS to reduce the cost and enhance the reliability of the aircraft. It is incorporated with a global positioning system (GPS) receiver and uses the latest fibre optic gyroscope-based inertial sensor. On April 29, 2009, Northrop Grumman delivered the last of 44 ex-Swiss Air Force aircraft to the US Navy for use as Aggressors in dissimilar air combat training (DACT).

The 41 single seat aircraft, now known as F-5Ns, along with three more converted from F-5Es to F-5F two seat trainers, were the subject of a major overhaul, including rebuilding the forward fuselages and upgrading various avionics at the St Augustine, Florida facility. These aircraft are now in service with VFC-13 and VFC-111 in Nevada and Florida, where they provide a very effective and inexpensive adversary force in air combat training.

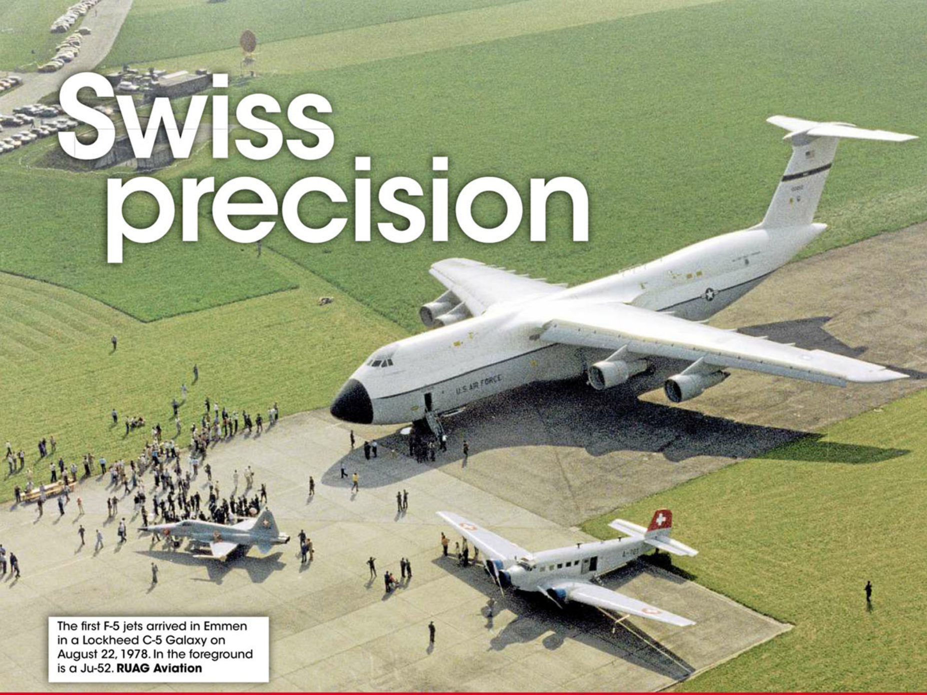
Aside from the upgrades offered by the manufacturer, several nations have upgraded their aircraft with equipment from other nations. Embraer and Elbit Systems have upgraded the F-5Es of Brazil with the FIAR Grifo F radar and other new systems, while Elbit has also upgraded the Chilean F-5Es with the Elta EL/M-2032 radar, giving both beyond visual range missile capability for the first time. Israeli Aircraft Industries (IAI) upgraded the F-5Es of Thailand, then partnered with Singapore Technologies Aerospace (STAero) to upgrade the Turkish fleet and with Sogerma for the Moroccan F-5Es and Fs. STAero has also upgraded its own Singapore Air Force F-5Es, as well as those of Saudi Arabia and the RF-5E reconnaissance aircraft of Taiwan.

All of these upgrades are described in more detail later in this issue. Many of the upgraded aircraft are intended to remain in service until 2020 or even later, by any standards a remarkable lifespan for a modern combat aircraft. Given that the engines and airframe are still remarkably airworthy and competitive in terms of both performance and operating costs, it is certain the Tiger will prowl the skies for many years to come.

■ *Words: Tim Callaway*

Three F-5Ns of VFC-13, The Saints, based at Fallon Naval Air Station, Nevada. **Jos M Ramos - RamosAviationPhotos.com**

Swiss precision



The first F-5 jets arrived in Emmen in a Lockheed C-5 Galaxy on August 22, 1978. In the foreground is a Ju-52. **RUAG Aviation**

The Swiss Air Force F-5 Tiger IIs - manufactured in the US and assembled in Switzerland

In the late Seventies, as the last de Havilland Venom was being retired and the Hawker Hunter was increasingly being used in the air-to-ground role, the Swiss Air Force was left with a gap in its area air defence. A gap which the Northrop F-5E Tiger II was to fill.

Secondly, the aircraft fully out of the C-5, its wings are alongside the fuselage. **RUAG Aviation**

The 1966 defence concept partly redefined the responsibilities of the Swiss Air Force. Its primary task became the general control and protection of Swiss airspace, i.e. the temporary and geographically limited protection of ground troops from enemy air strikes by maintaining sovereignty over the airspace. This entailed the procuring of a large number of so-called Raumschutzjäger, fighter aircraft specifically designated for area air defence, to replace the outdated Swiss Hawker Hunters. The new aircraft were to be chosen according to three crucial factors. Firstly the price. Secondly, the aircraft had to be suitable for reservist militia pilots as well as professional pilots. Thirdly, they had to be able to be stationed in the caverns of the mountain airfields.

Before any new aircraft were procured, the different types available at the time, including the American F-5 Tiger II, the French Mirage F.1 and the British Hawker Siddeley Harrier GR.1, were thoroughly evaluated. The Swiss Federal Council had, however, decided quite early on to focus on one aircraft – the F-5 Tiger II. This evaluation took place in 1973 and 1974.

EVALUATION

Strictly speaking, the F-5's history in Switzerland began on August 12, 1974, at 11.50am. It was at this time that the first aircraft landed in Emmen from California – an aircraft that would go on to decisively shape events at the Swiss Federal Aircraft Factory in Emmen (F+W) and in Swiss airspace. The US Air Force (USAF) F-5 Tiger II (serial 01386) stayed in Emmen until September 20 and flew – together with a second aircraft – a number of test missions, mock air-combats against Mirage and Hunter aircraft and weapons trials. The two F-5s, one of which was equipped with a flight data recorder to monitor its performance, completed a total of 60 test flights altogether.

SIGNING THE CONTRACT

Convinced by the F-5 Tiger II's performance throughout the evaluation process, the Swiss parliament approved the purchase of 72 aircraft for a total of 1.17 billion Swiss francs on March 16, 1976. The Peace Alps program as it was known included 66 single seaters (J-3001 to 3066) and six two-seaters (J-3201 to J-3206), for which the procurement contracts

Three images depicting the unloading of the F-5 in Emmen on August 22, 1978. Removing the palletised aircraft from the C-5 is a delicate operation. **RUAG Aviation**

were signed on March 30, 1976. F+W director Lucien Othenin-Girard signed a supplementary licensing contract worth 40 million Swiss francs with Northrop for the final assembly of the fighter jets. Under the agreement, the Swiss Federal Aircraft Factory would handle the final assembly of 53 single seaters and the re-assembly of 13 single seaters and six two-seaters. It also covered the transfer of knowledge for the final assembly in the broadest sense by regulating the documentation, tools and test appliances, staff training at Northrop and Northrop's assistance in Emmen down to the last detail.

Representing the interests of the Swiss Military Department (EMD), the following institutions were involved in the contract process: the Gruppe für Rüstungsdienste (GRD, armaments services group) with its technical and commercial departments and the Swiss Federal Aircraft Factory Emmen (F+W); the KFLF, which was in command of the Swiss air force and anti-aircraft troops with various departments, in particular with the AMF, the military airfields division and the GGST, group for General Staff. René Huber of the GRD was the senior project manager, Rolf Immenhauser (GRD) the technical project manager.

The American partners involved were the Department of Defense (DOD); the USAF; Northrop as the manufacturer of the aircraft and General Electric as the engine manufacturer.

FINAL ASSEMBLY IN SWITZERLAND – WHY?

The decision to assemble the F-5 Tiger II in Emmen – the first 19 aircraft were only ordered fully assembled due to time constraints – was made following a meticulous assessment procedure carried out by an expert commission. In the end, the deciding factors for bringing the final assembly to Emmen were the hundreds of jobs it would secure over years to come, as well as the knowledge and expertise about the maintenance of the fighter over its entire service life that would be acquired at the same time. Initially, various alternatives had been discussed, including the full manufacture of the F-5 in Switzerland and the purchase of ready-for-use aircraft from the US. But as the manufacture of larger parts of the aircraft in Switzerland would have cost an additional 100 to 150 million Swiss francs, the Swiss contracting unit, the armaments service group, decided to focus on two options: purchasing the fully assembled aircraft from the US or assembling the aircraft in Switzerland. In early July 1975, the Federal Council reached a final decision: the aircraft would be assembled in Switzerland. Emmen was chosen as the single location for the final assembly as it would have been too expensive to spread it over various companies.

MECHANICS, ENGINEERS, METALWORKERS AND TECHNICIANS LEARNT HOW TO "PUT TOGETHER" SOME 7000 COMPONENTS TO BUILD AN F-5.

STAFF TRAINED IN THE US

In preparation for the final assembly in Emmen, staff had to undergo intense training including 28 separate courses in the Northrop plant in the US. This in-depth training introduced the Swiss Federal Aircraft Factory (F+W) staff to all the different aspects of the final assembly. Mechanics, engineers, metalworkers and technicians learnt how to put together some 7000 components to build an F-5. A documentation unit also had to be put in place to maintain all the technical documentation.

PRE-ASSEMBLY IN THE US

The first 19 of the Swiss F-5s were fully assembled by Northrop in Palmdale, California, between August 1978 and April 1979 before being flown into Switzerland. Each plane had a lead time of around three months including assembly and delivery to Switzerland. The 19 aircraft were 13 F-5E single seaters (J-3001 to 3013) and six F-5F two seaters (J-3201 to J-3206). Once manufactured, these F-5s were inspected by the US Air Force before they took delivery and flew them to the McClellan Air Force Base near Sacramento, where the wings and tail fins were dismounted and the fuel and oxygen systems emptied for safety, ready for transport. The dismantled parts were fixed on a special transport cradle together with the fuselage. The transport cradles were then ➤

loaded into the cargo hold of a Lockheed C-5A Galaxy and fixed with a fast lock system, ready for delivery to Switzerland.

This method of transportation was the least expensive alternative. To fly all 19 Tigers individually, the pilots would have had to make several intermediate landings, which would have required an expensive logistical infrastructure.

40,000 SPECTATORS

On August 22, 1978, a large number of guests from business and politics led by Federal Councillor Rudolf Gnägi, with around 140 journalists from all over Switzerland and some 40,000 excited spectators,waited in the scorching afternoon sun to witness the arrival of the first fully assembled F-5Es on board the Galaxy. The Tigers were transported into the assembly hall on the transport cradles. The remaining aircraft arrived in Switzerland on September 21 and October 18, also on board a Lockheed C-5 Galaxy.

The line of F-5s being taken into the factory for assembly. **RUAG Aviation**

PREPARATION FOR FINAL ASSEMBLY IN EMMEN

For close to two years between the beginning of the project in April 1976 and late 1977, work in Emmen mainly involved the preparation for the final assembly programme: setting up the project organization, detailed planning and introduction of ongoing schedule and cost control; setting up a central technical documentation unit for the project serving all Swiss units (at the end of the project the unit had more than 12 tons of documentation); training staff in all areas, partly in the US and partly internally or at the AMF; design and construction of systems, equipment and test instruments and setting up the assembly line.

From November 1977, assemblies and material for the final assembly were flown from Los Angeles to Emmen about every two weeks on L-100-30 Hercules transporters – over a total of 28 flights. The assemblies consisted of front, middle and rear sections of the aircraft fuselage, wings and horizontal stabilizers as well as numerous other parts including nose gears, airbrakes, flaps and canopies. General Electric delivered the engines directly from Boston to Kloten. Other material came to Switzerland as sea or air freight. The 53 aircraft assembled in Emmen (J-3014 to J-3066) had been manufactured at the Northrop sub-assembly line in Hawthorne, California, before being pre-assembled and partly fitted at the final assembly line 150km away in Palmdale.

FINAL ASSEMBLY

Experts from Northrop and General Electric were stationed in Emmen throughout 1977 and 1978, with a peak in the first six months of final assembly. They offered support mainly in the areas of engineering, quality assurance, laboratory testing and assembly. The Swiss staff worked with supplied original American documentation in all areas of the project.

Final assembly officially started in January 1978 with Northrop fitting the front and middle sections of the first two aircraft bodies (J-3014 and J-3015), followed by the remaining 51 aircraft being fitted by the Swiss Federal Aircraft Factory (F+W). Once the production output level reached a stable 2.5 fighters per month, each aircraft had a lead time of around eight months. The individual stages of assembly were divided into cost centres. Work began with the simultaneous fitting of the front and middle sections of the aircraft fuselages, including installations in the engine bay (e.g. fire warning system) and in the electric and hydraulic systems.

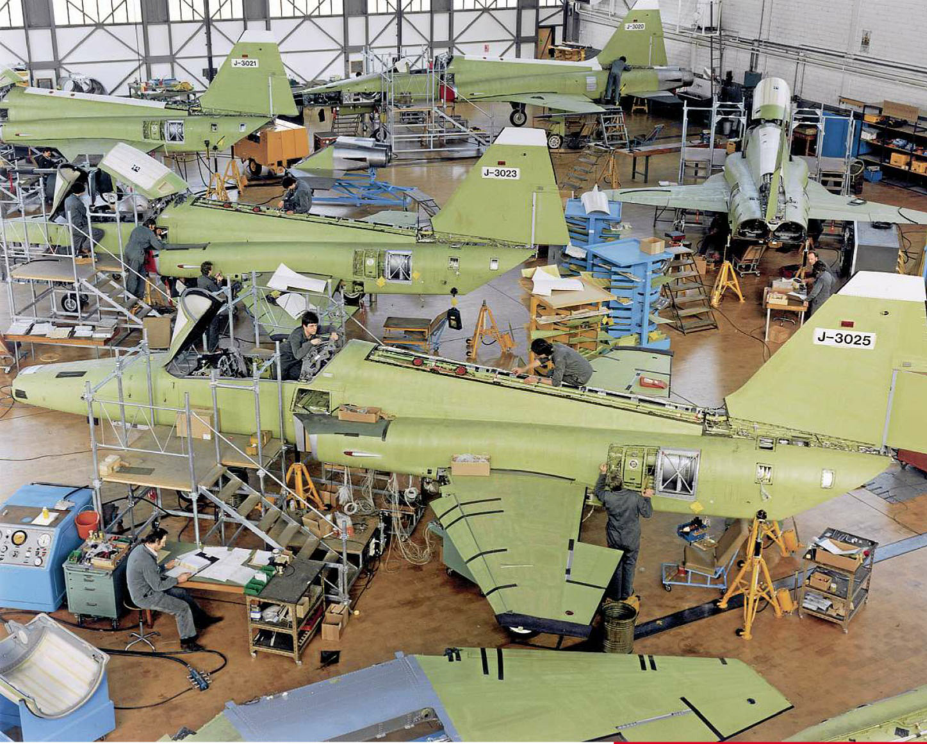
Taking the F-5s off their palettes to begin assembly inside the Emmen facility. **RUAG Aviation**

In the next step, the fuselage was put together and the wings were assembled, as were the tailplane, nose gear, canopy, windshield and oxygen system. Installations in the cockpit and avionics equipment bay were carried out at the same time. After this, the other devices and generators that had previously been fitted and tested on left and right engines were mounted and tested, followed by extensive function checks of the various systems, the assembly of other parts, e.g. antennas and ejector seats, and as a last touch, the application of the camouflage finish. The final checks meant the end of the actual assembly program and were only followed by the weighing of the aircraft, static testing and the firing of the guns on the ground.

Despite the 13,000 kilometre distance, the final assembly line in Emmen was nearly identical to the one in Palmdale.

'HELVETIZED' F-5

In order to adapt them to the specific geographical and meteorological conditions as well as the operational and maintenance structures in Switzerland, certain modifications were made to the aircraft – a so-called 'helvetization'. The most significant modifications included the single seaters being equipped with an oxygen system using gaseous rather than the more common liquid oxygen as the use of liquid oxygen would have been too dangerous for the operation inside the caverns of the mountain airfields. This gaseous oxygen system was designed in the Swiss Federal Aircraft Factory (F+W) and manufactured for the entire fleet of single seaters. Instead of using a spherical tank, this



Above: A glimpse of the final assembly hall at the Swiss Federal Aircraft Factory in Emmen. **RUAG Aviation**

system was built around four cylindrical pressure containers filled with a total of 2200 litres of gaseous oxygen. As the caverns are narrow and moving the aircraft occasionally required the use of a crane, the existing lifting points on the F-5 were reinforced.

An additional radio unit was installed in the aircraft due to the weak radio coverage in parts of the Swiss mountains. To make it easier to land on wet, snow-covered or icy runways and to meet the challenges of approaching the Swiss mountain airfields, the wheel brakes were fitted with an anti-lock brake system. Anticipating a prolonged use of the aircraft by the Swiss air force, a fatigue meter was installed, which measures and records the load factors for every flight, thus allowing staff to monitor and control airframe fatigue.

Two important aircraft instruments, the altimeter and variometer, were replaced with Swiss devices showing metric units. A special survival kit was developed in case of any pilots having to use their ejector seats above the Swiss mountains. None of these modifications had an influence on the Tigers' flight performance.

MAIDEN FLIGHT

On August 29, 1978, at 4.05pm, the first Swiss-assembled Tiger aircraft with the serial J-3014 took off for its 49 minute maiden flight with GRD chief pilot Jean Brunner in the cockpit. The maiden flight went smoothly and J-3014 was delivered to the Swiss forces as the first 'Swiss Tiger' on October 10, 1978. Provided no defects demanded any repeat testing, the flight program generally consisted of three flights: a first flight for airframe and engines, a second for the avionics system and a third for the navigation system and guns.

Final assembly of the last aircraft to go through the plant in Emmen, J-3066, began on July 21, 1980. It took off for its maiden flight on February 13, 1981, and was delivered to the BAMF (Bundesamt für Militärflugplätze, the former AMF) on April 9, 1981, during a small celebration. In the course of this celebration it was also announced that the Swiss Tiger-fleet had at this point already logged some 10,000 hours of flying time.

ENGINE

The final assembly of the F-5 also led to the Swiss Federal Aircraft Factory in Emmen taking on other interesting projects. As part of the Offset program, the F+W research unit was commissioned by General Electric to conduct part of the fatigue strength testing for the J-85-GE-21 compressor and turbine ➤

THE MOST SIGNIFICANT MODIFICATIONS INCLUDED THE SINGLE SEATERS BEING EQUIPPED WITH AN OXYGEN SYSTEM USING GASEOUS RATHER THAN THE MORE COMMON LIQUID OXYGEN AS THE USE OF LIQUID OXYGEN WOULD HAVE BEEN TOO DANGEROUS FOR THE OPERATION INSIDE THE CAVERNS OF THE MOUNTAIN AIRFIELDS. AS THE CAVERNS ARE NARROW AND MOVING THE AIRCRAFT OCCASIONALLY REQUIRED THE USE OF A CRANE, THE EXISTING LIFTING POINTS ON THE F-5 WERE REINFORCED.

Complete assembly took around eight months per aircraft. **RUAG Aviation**

engine. The testing procedure consisted of 4800 cycles of alternate loading, half of which were carried out in the US in 1977, while the other 2400 were spread over three separate trial periods at the engine test bench in Emmen. This allowed the F+W engine specialists to gain valuable know-how regarding the maintenance of this engine.

WIND TUNNEL EXPERIMENTS

The research unit also produced its own F-5 models for wind tunnel experiments. This allowed them to establish a basis on which to make any adjustments to the aircraft's airframe and to obtain the necessary information for the integration of external loads using tried and tested models and measuring equipment, both within a reasonable time and independently of foreign partners. Three models were built for this purpose.

A full model of an F-5E was built at a scale of 1:3.5 for measurements in the Large Subsonic Wind Tunnel. The model's body was made of steel and light metal as well as a glass fibre-reinforced plastic cladding for the exterior shell, and it also had all the external parts. A half-model of an F-5E at a scale of 1:25 and a full model at a scale of 1:40 were also produced for testing in the transonic tunnel. All the models could be converted to the two seater F-5F and RF-5E reconnaissance aircraft configuration.

SECOND BATCH

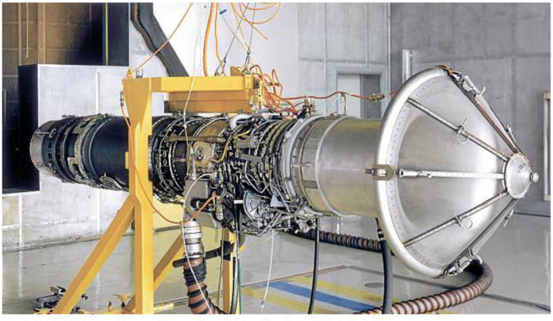
Based on the F-5's reliable performance in daily operations for both professional and militia pilots, a second batch of Tiger aircraft was ordered in 1981 under the Peace Alps II armament program. Thirty-two single seater F-5E (J-3067 to J-3098) and six two-seater F-5F (J-3207 to J-3212) aircraft were ordered for a total of 770 million Swiss francs. The corresponding contracts were signed in Berne on July 1, 1981.

THE PEACE ALPS II PROGRAM INVOLVED THE SWISS INDUSTRY IN THE ACTUAL PRODUCTION OF THE AIRCRAFT.

The Peace Alps II program involved the Swiss industry in the actual production of the aircraft, as various assemblies were manufactured under licence in Switzerland. The production of some of these assemblies in Switzerland had a long-term effect that can, in some cases, still be felt up to this day.

Final assembly was also carried out in Emmen, between mid-1983 and early 1985, with the last Tiger (J-3098) being delivered to the Swiss Air Force on March 27, 1985, bringing the total number of F-5E/F fighter aircraft in Switzerland to 110. ■

Words: RUAG Aviation



Each J-85-GE-21 engine underwent individual testing. **RUAG Aviation**

RUAG: EXPERIENCE GAINED FROM THE F-5 FINAL ASSEMBLY PROGRAMME ENABLES SUPPORT FAR BEYOND DEPOT-LEVEL MAINTENANCE

As a long-standing partner of the Swiss Air Force, RUAG Aviation has extensive experience when it comes to maintaining fighter jets. During the procurement of the F-5 Tiger it was involved right from the evaluation stage. Today RUAG Aviation provides a broad range of service assistance for the entire F-5 system. Its responsibilities include structural parts, engines, avionics, and devices, including the associated support, testing and training equipment together with systems integration. F-5 operators the world over benefit from RUAG Aviation's extensive expertise and broad experience in logistics, engineering, maintenance, repairs and upgrades. Daniel Brunner, general manager of jet and missiles at RUAG Aviation, has huge experience when it comes to maintaining F-5 aircraft. He tells us more.

Daniel, how many major (300 hours) and interim (150 hours) inspections have been performed in Emmen?

I have quite precise figures for this. In early 2013 the total number of hours employed on the Swiss Tiger fleet was 260,174. Since 1978, 867 major and 1000 interim inspections have been performed. Of these inspections, around 80% were the responsibility of RUAG Aviation while the air force was responsible for 20%.

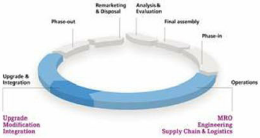
The F-5 has been in use by the Swiss air force since 1978. At present, 54 aircraft continue to be in service. How have these aircraft changed over the past 35 years?

RUAG Aviation works in close collaboration with the Swiss air force and the Swiss procurement office armasuisse, and is responsible for the entire lifecycle of the aircraft. This began through support in the initial evaluation and continued with final assembly. There followed maintenance, upgrade, modification, and at some point the history of Switzerland's F-5s will end with the decommissioning and possible sale of the aircraft.

Coming back to the original question, this means that over the past 35 years RUAG Aviation has implemented around 450 modifications to the F-5 – from the air frame and ejector seat to structural improvements. I would like to mention just three projects by way of example. The first is Improved Handling Quality (IHQ). This involved improving the handling of the aircraft for the pilot through three changes: LEX extension, automatic leading edge wing flaps and the Shark Nose radome. Then there was the installation of a smoke generator in the F-5 of the Swiss aerobatic team Patrouille Suisse. Finally, there were modifications in the areas of communication and navigation to the F-5s leased to the Austrian Air Force for four years.

As a result of our extensive F-5 expertise, we have developed optimised repair processes and established an efficient fleet management for inspections. We are investing in testing systems and testing equipment on an ongoing basis and also possess considerable knowledge and experience in this area.

Daniel Brunner, general manager for jet and missiles at RUAG Aviation. **RUAG Aviation**



A Patrouille Suisse F-5 under maintenance. **RUAG Aviation**

As can be seen in these three images, RUAG Aviation maintains the entire F-5 fleet of the Swiss Air Force. **RUAG Aviation**

For which components has RUAG Aviation received the authorisation from original manufacturer Northrop to perform the servicing? At what level?

For the Swiss Air Force's F-5s we have the licences and agreements to maintain all structural components and parts – without restriction. Consequently, we possess all the technical documents and data packages. This enables us to look after the Swiss F-5s throughout their entire lifecycle. Although we are still subject to some restrictions at an international level, we are resolving them on a case-by-case basis, working in partnership.

What is the situation regarding the General Electric J-85-GE-21B/C engine in this respect?

For engines we are able to offer full maintenance the world over without restriction. We maintain and repair both complete engines or just modules or individual parts. We also offer maintenance training and on-site technical support. Moreover, we are increasingly aiming to collaborate with international maintenance firms. Our big advantage in all these activities is that we only ever use the original manufacturer's spare parts.

What about guided missiles?

In addition to the F-5 and its components, RUAG Aviation – in close collaboration with the US Air Force – is also the system administrator for the AIM-9P air-to-air guided missile. Our services here are not limited to the depot level either but they also include design and redesign work.

RUAG Aviation also offers its F-5 services to other air forces. What authorisations are required for this?

We require authorisation from the US State Department and from the original manufacturer, and all transactions are subject to the International Traffic in Arms Regulations (ITAR). An export licence from the Swiss State Secretariat for Economic Affairs (SECO) is also required.

We serve our international customers in two ways. First of all, via US Foreign Military Sales (FMS). In this case, we become the partner of foreign governments. Secondly, the customer can buy services directly from us.

The Swiss Air Force currently has 54 F-5 jets still in service. **RUAG Aviation**

An F-5 wing being refurbished. **RUAG Aviation**

For which countries has RUAG Aviation provided services on the international F-5 market in the past?

I can summarise the answer in one sentence: We have provided services in one form or another for virtually all F-5 operators around the world.

Switzerland is not exactly known as a low-wage country. Does RUAG Aviation make up for this handicap with its expertise and quality? Are there other benefits as well?

In addition to the renowned Swiss quality, certain disadvantages in terms of price are offset above all by the high availability of spares, the access to the required repair solutions and the short turnaround times. Our customers know that although Swiss quality costs slightly more, the turnaround is fast and everything works – and via RUAG Aviation you have access to all spares.

Where does RUAG Aviation see the biggest prospects for success regarding the maintenance of the F-5 and its components?

We enjoy a big advantage, namely that no end of life is defined for the F-5 and that it is still a very popular and accordingly widely spread aircraft model despite having been in service for more than 40 years. This is our opportunity. Thanks to our long-standing expertise with this aircraft we are able to offer service packages that extend the lifecycle by years. Moreover, we ourselves or in collaboration with the manufacturer are able to offer components for many years to come. The fact that some air forces are hesitating to procure new fighter jets is proving to be an advantage for us. It allows us to support the operation of the Tiger fleets competently and for a greater length of time.

Would you hazard a look into the future?

RUAG Aviation has set itself the goal of establishing long-term partnerships with manufacturers and operators of select aircraft models, components and spare parts. In Switzerland such a partnership exists for the F-5 with procurement authority armasuisse, the Air Force, the Swiss army's logistical basis and the manufacturer for the entire lifecycle. This works wonderfully and shows us the way forward. We want this to be our model of success for the future! In this context, I would like to stress very clearly that we always act as a service provider in all projects - always in close collaboration with our partners. ■

The essence of precision and reliability, the Patrouille Suisse.
Luigino Caliaro

The Tiger and the Corsair

Portugal's aircraft were obsolete by the end of the Colonial War and a modern replacement was desperately needed. As an American ally, the nation decided to buy the Northrop F-5E Tiger II, but severe financial shortcomings led to the Vought A-7P Corsair II being picked instead. The US was not the only country to offer the F-5 to Portugal however...

After the war in Africa the Portuguese air force, the Força Aérea Portuguesa (FAP), needed modern jet fighters. By that time its entire inventory was comprised of worn-out and obsolescent aircraft. Its main fighter was still the F-86F Sabre, with plans for its replacement presented to NATO in 1976, and the other jet was the Fiat G.91, both machines being inadequate for European operations.

Shortly before the revolution of April 25, 1974, the Government tried to acquire a batch of French Mirage fighters as I discussed in Issue 17 of *Aviation Classics*. There were also talks regarding the purchase of F-5Es from a German company, but the arms embargo placed over Portugal by the US, which didn't agree with the war in Africa, made this impossible. Finally the possibility was also considered of purchasing Italian G.91Ys, a twin-engined version of the old Fiats. None of these deals came to fruition as the Government that came after the revolution didn't prioritize the modernization of the armed forces, and thus any acquisition of new material had to rely on North American support, using the lease payments for Lajes airbase in the Azores to generate funds. Talks started as early as June 1974, with a series of meetings between the Chief of Staff of the Air Force (CEMFA) of the time, General Diogo Neto, and Colonel Wilkerson, section chief from the Military Assistance Advisory Group (MAAG) based in the American embassy in Lisbon.

A pair of FAP Fiat G91R.3s in flight. These aircraft were used as both fighters and ground attack aircraft by Portugal. **SDFA/AH via Jose**

THE AIR FORCE'S PLANS

The FAP objective was to equip two squadrons with fast jets, the first with Northrop F-5E Tiger IIs, and the second with McDonnell Douglas F-4E Phantom IIs. There were also requests for Northrop T-38 Talon trainers to replace the old T-33s and T-41 Mescaleros to take the place of the ageing Chipmunks. The magnitude of the request surprised the Americans, who reminded Portugal that the arms embargo was still standing, which in reply prompted Diogo Neto to state that these aircraft were to be used in Europe only.

Regardless, Colonel Wilkerson had doubts regarding the capabilities of the Portuguese to pay for that equipment, referring them in his contacts with the US Department of State. He also questioned the lack of references to any antisubmarine aircraft like the Lockheed P-3 Orion, a model that had already been requested by the previous government before April 25. The fact though was that those aircraft were also part of the ample modernization plans envisaged by the FAP, plans that clearly surpassed any support that the US could give to Portugal. The Portuguese plans are presented in the table below.

THE GERMAN SUPPORT

Beyond the payments for the Lajes airbase, Portugal also relied on help from West Germany in the scope of the agreements regarding Bejas airbase, used by the Luftwaffe. In November 1975 a protocol was negotiated, in Bonn, regarding the delivery to Portugal of six Fiat G.91 T3 aircraft (training two-seaters) with spares, ground support and test equipment and their respective documents. Also included were 12 single seat R3 jets, from LeKG Pferdsfeld, which the Luftwaffe was retiring. It also authorized the training of personnel in Germany. Eventually the deal was changed to include 14 single seaters. Unfortunately the aircraft ended up being in bad condition, which created some embarrassment in Germany, which would only be solved when Germany instigated an Inspect and Repair As Necessary (IRAN) programme through Dornier. More importantly, these were still outdated aircraft and did not solve the Portuguese need for modern jets.

WORRIES WITHIN NATO

The Portuguese situation was followed with concern by NATO. In a secret telegram dated November 21, 1975, the American delegation in NATO discussed several uncertainties about the Portuguese ability to deliver its responsibilities within the organisation. Regardless of the jet fighters being requested by the Portuguese, the American authorities believed that models more apt for maritime strike missions, like the A-7D Corsair II or the A-4N Skyhawk, would be preferable. We need to take into account that in NATO's plans of the time, Portugal was considered a backwater country, and in the case of war with the Eastern Bloc, its priorities would be securing the arrival of shipments by sea, thus Portugal needed to be able to neutralize Soviet surface threats.

Even without regarding the real numbers for the American funding, the FAP kept

Instead of the F-5, an agreement was made to purchase the Vought A-7P Corsair II in 1979. **SDFA/AH via Jose Matos**

MODERNISATION PLANS

Years	Primary Trainer T-41A	Basic Training T-37C	Advanced Training T-38	Tactical Cooperation F-5E	Air Defence F-4E	Helicopters Bell 209 AH-1Q	Maritime Patrol P-3C	Tactical Transport C-130
1975	15	5	8	12	8	15	2	2
1976	5	5	7	8	8	20	2	1
1977		5	5	12		15	2	1
1978							2	
1979								
Total	20	15	20	32	16	50	8	4

A FAP Fiat G91R.3 in a 'Tiger Meet' colour scheme. **SDFA/AH via Jose Matos**

developing its modernization plans with the F-5E always seen as the preferred choice. It was expected to be bought through the Military Assistance Program (MAP) and the Foreign Military Sales (FMS) department. Regarded as the 'poor man's fighter', it was especially geared to anti-aircraft operations, with limited air-to-ground capabilities. The previous model (F-5A Freedom Fighter) was actually seeing widespread use in Europe by that time, having been produced in Spain and the Netherlands. The E model was less popular in the region though, with Switzerland being the only European customer. The Portuguese interest was obvious and the arrival of six T-38s leased from the United States in 1977 seemed to show that the acquisition was already under way. But that was not to happen.

CHOOSING THE A-7

A decisive meeting took place on November 15, 1979, between representatives from the Pentagon, the American embassy in Lisbon and General CEMFA Lemos Ferreira and several FAP senior officers. Three options were on the table for the fulfillment of the modernization program, the first proposed the acquisition of 20 F-5Es with a cost of 120 million dollars. As the Lajes accord accounted for just 72 million, a 48 million loan from the FMS was needed, with 10% interest rates. This option was unsupportable and didn't offer enough spares or a sixth C-130 Hercules, which the force thought vital for operations. Another option was to acquire 12 F-5Es, this time for 79 million dollars. This still required a loan of seven million dollars, negated the possibility of furnishing two squadrons and still didn't allow for the sixth C-130.

Finally, there was the possibility of buying 30 A-7As for 49 million dollars, offering enough spare budget to acquire the sixth Hercules. This was obviously the superior option, although the aircraft were already old. It was decided that the A model could be reconfigured with new avionics and Pratt and Whitney TF30-P-408 engines. The A-7A used an earlier engine, the TF30-P-6, which didn't hold that much interest for the FAP. The installation of the TF30-P-408 didn't require major changes to the aircraft and had the advantage of being a better engine. As for the avionics, they could also be updated. This way, the Portuguese option for the A-7P program was drawn up, and contract V-519 was negotiated and signed on May 5, 1980. This fell within the scope of the Military Assistance Program, seeing the acquisition of 20 aircraft in the first phase. In the final version, the A-7P was brought to the avionics level of the A-7E, along with the TF30-P-408 engine. ➤

The remarkably clean lines of the T-38 Talon are clear in this view of one of the initial batch of six Portuguese aircraft. **Luis Rosa**

The T-38 was the perfect jet trainer and increased Portugal's resolve to acquire the F-5. **SDFA/AH via Jose Matos**

The work of preparing and assembling the first lot of aircraft was performed by the Vought Corporation in Dallas, and the first A-7P (5501) took to the skies in July 20, 1981. Meanwhile, by August 17, a group of Portuguese pilots and technicians was sent to Vought to make the transition to the new aircraft. The mission's leader was Lieutenant-Colonel Victor Manuel Silva, along with seven other pilots. On September 12, a second group was also sent to Dallas to be acquainted with the aircraft. At the end of the year, once the instruction was over, it was decided to send the first nine aircraft on a long trip from Dallas to Monte Real, using the Dallas-Bermudas-Azores-Monte Real route. This was the most direct and simple route, and a C-130 from 501st Squadron was mobilized to act as support. The aircraft departed on December 21, crewed by six Portuguese pilots and three crewmen from Vought. They made a stopover in the Bermudas and another on the following day, in Lajes. Finally they arrived in Monte Real on December 24, having been grounded for a while due to bad weather.

The official delivery of the new aircraft happened on January 8, 1982, on Transit Airfield Nº1 in Lisbon, in the presence of General CEMGFA Melo Egídio, General CEMFA Lemos Ferreira, the Minister of Defence, the Secretary of State and the American ambassador in Lisbon, Richard Bloomfield.

COMPARISON

Although it was not a supersonic aircraft, the A-7 had greater range and payload, and also enjoyed superior avionics, being capable of fulfilling a wider range of roles. More so, it was much better prepared for the kind of antishipping operations required for the FAP in its NATO role. It could also use its two 20mm cannons and two AIM-9 Sidewinder missile racks to perform air-to-air operations, although that wasn't its intended role. For all effects and purposes, the air cover for the Iberian Peninsula would be imparted to Spain and the F-16s of the 401st Tactical Fighter Wing, based on Torrejón de Ardoz, just outside Madrid.

A NORWEGIAN OFFER

Even with the purchase of the A-7, the possibility of obtaining F-5s was still on the table, in particular aircraft from Norway. From 1979 this Nordic country had shown a willingness to provide military help to Portugal and Turkey with the transfer of F-5A/Bs. The Northrop jet had been in service with the RNorAF since 1965, and in the late 70s Norway had three squadrons of F-5s with 69 operational aircraft (versions A, B and R). General Ferreira sent two officers from the Monte Real airbase to Norway to evaluate the aircraft. Based on the inspection report and the technical documentation, EMFA's 3rd Division considered that "the receipt of a squadron of F-5A/Bs would be a bridging solution acceptable in all aspects including logistics". But with the acquisition of the A-7 in progress, the Norwegian plan didn't see any progress until 1982. In October of that year, the RNorAF announced that it had 11 F-5As to offer, but with cracks on the air intakes that required repairs. Although the aircraft could fly, the cost of repairing those cracks amounted to $50,000 per aircraft. The jets would be sold for a symbolic price, but shipping and repair costs were to be met by Portugal. In response, the air force remarked that it remained interested in the transfer of the F-5s, but preferably two-seater aircraft.

Some months later, in July 1983, the Inspector-General of the RNorAF reported that Norway intended to keep all of its two-seater F-5s and 30 F-5As. Given this information, the FAP admitted that in that case it "would have to look for other alternatives", such as

Fiat G91R.3s and a two seat G91T.3. These aircraft, though capable strike fighters on introduction, badly needed replacing by the 1970s. **SDFA/AH via Jose Matos**

The FAP A-7Ps were optimised for ground attack and surface strike to best meet Portugal's commitments to NATO. **SDFA/AH via Jose Matos**

Seen here carrying ground attack rocket pods, the FAP A-7Ps had improved engines and avionics. **Paulo Mata**

An initial batch of six T-38 Talons were leased from the US in 1977. **SDFA/AH via Jose Matos**

A-7P AND F-5E PERFORMANCE COMPARISON

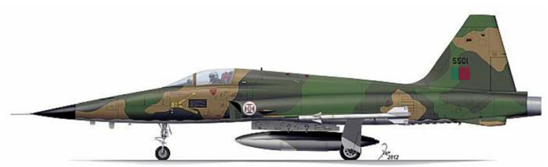
Characteristics	A-7P Corsair II	F-5E Tiger II
Length	14.06m	14.45m
Wingspan	7.24m (folded wings)	8.15m
Empty weight take off maximum	7337kg 19,050kg	4410kg 11,215kg
Engine	A Pratt & Whitney TF30-P-408 turbofan without afterburner	Two General Electric J85-GE-21 with afterburner
Thrust	6074kg without afterburner	2270kg each with afterburner
Max speed (sea level)	1123kph	1140kph
Weapon load	6805kg on six wing stations and two fuselage stations	3175kg on six wing stations and one fuselage station
Fixed weaponry	Two MK 12 20mm cannon	Two M39AZ 20mm cannon
Service ceiling	12,545m	15,790m
Combat radius (loaded)	1150km	220km
Radar	AN/APQ-126 with several air-surface operation modes	AN/APQ-159 radar optimized for air-to-air operations
Other equipment	UHF/VHF, IFF, VOR, RWR, TACAN, HUD, Pave Penny, navigational Doppler radar, inertial navigational system, tactical computer	UHF/VHF,IFF, VOR/ILS (optional), RWR (optional), TACAN+ADF, Visor AN/ASG-31,inertial navigational system (optional)

accepting some F-5As. But in November 1984 it was Washington that offered four F-5As and two engines to Portugal.

This proposal prompted the air force to ask the US authorities about the status of the aircraft and in response to the request for information it was reported that the four aircraft had more than 3000 flight hours, very close to the maximum time of service calculated for the F-5A (4000 hours). Moreover, it was suspected that they had the same problems concerning cracks in the structure and air intakes to the Norwegians F-5s. Around the same time, the RNorAF made a new offer to Portugal. This time 15-20 F-5A/Bs were offered, a sufficient number to form a squadron, but both deals ended up being declined by the air force, due to the many flight hours on the airframes and the fact that they represented an older version of F-5. Without an air defence fighter, it would be down to the A-7 to fill this role and to defend the Portuguese airspace.

The author would like to give his thanks to the Arquivo Histórico da Força Aérea (SDFA/AHFA) and to the Arquivo da Defesa Nacional (ADN), to Jose Correia for the memorandum on the Norwegian issue and finally to General Lemos Ferreira for comments and clarifications.

■ *Words: Jose Matos*



This side view shows how the F-5E would have appeared in FAP service. **Paulo Alegria**

The Royal Norwegian Air Force offered Portugal various combinations of F-5s from its stocks of the aircraft. **Jan Jørgensen**

The F-5 Abroad

The F-5 and its customers worldwide

Aside from the United States, which is covered earlier in this magazine, 37 other countries have used the F-5 and T-38, a remarkable record of success for the aircraft. Many are still in service today, and are likely to remain so until at least 2030 due to the original fighter's remarkable performance and reliability; and a number of equipment and capability upgrades by users around the world.

Before and after – A Saab J35Ö Draken with a Northrop F-5E Tiger II of the Austrian Air Force. **Luigino Caliaro**

A Northrop F-5EM of the Brazilian Air Force on a tanker exercise. **Chris Lofting**

This is a list of all the countries that have operated the F-5 and T-38 and includes the upgrades and variants produced during the type's 54 years of operational service as well as a table of the total numbers built by Northrop and under licence in various countries.

AUSTRIA

Having been flying the Saab J35Ö Draken as its front line fighter since 1985, in July 2002 the Austrian Air Force selected the Eurofighter Typhoon to become its new air defence fighter. The first Typhoon was not delivered until July 2007, so between July 2004 and July 2008, 12 Northrop F-5E Tiger IIs were leased from the Swiss Air Force as the last Draken was retired in December 2005. The F-5s fulfilled the air defence role and were returned to Switzerland as the Typhoon delivery progressed.

BAHRAIN

The Bahrain Defence Force (BDF) was first established in 1977 and was intended as a purely defensive force of combined army, navy and air force units. Its first jet fighters, eight F-5Es and four F-5F trainers were supplied from stocks held in the United States in two tranches ordered in 1982 and 1985. Four more F-5Es were added in 1987, the same year the BDF was separated into the Bahrain Amiri air force, army and navy. These aircraft remain in service today, alongside 22 F-16Cs and Ds purchased in 1990, and are based at Sheik Isa Air Base.

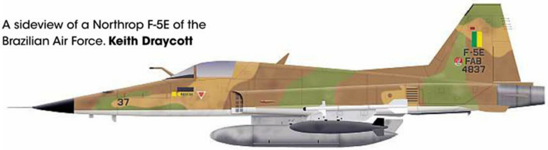
BOTSWANA

The air wing of the Botswana Defence Force purchased 10 upgraded ex-Canadian Armed Forces Canadair CF-5As and three CF-5Ds from Canada in 1996 to replace its BAC Strikemasters. Three more CF-5As and two CF-5Ds were purchased in 2000 to replace losses in the single seat force and supplement the country's training capability. Nine CF-5As and all five two seaters remain in service today.

BRAZIL

Brazil ordered 37 F-5Es and six F-5B two seat aircraft in October 1974, the F-5Bs being the last of the version to be built by Northrop. The aircraft entered service in March 1975, replacing the Gloster Meteor F8 and Lockheed P-80 Shooting Star as Brazil's front line fighters. In 1987, the fleet was supplemented by 22 ex-USAF F-5Es and four F-5F two seaters assembled from spare parts so essentially brand new aircraft. These four F-5Fs replaced the F-5Bs. In 1998 Elbit of Israel alongside Embraer won a contract to upgrade the Brazilian F-5 fleet, known as the F-5UP programme. This upgrade includes fitting the FIAR Grifo F radar, a new navigation system and avionics enabling the carriage of a wider range of air-to-air missiles. A total of 45 F-5EMs and three F-5FMs were produced to this standard by 2007. In September that year, eight more F-5Es and three F-5Fs were purchased from the Royal Jordanian Air Force, to be upgraded to the F-5EM standard. These aircraft are still in service with four units of the Brazilian Air Force and are likely to remain so until at least 2030. ➤

A sideview of a Northrop F-5E of the Brazilian Air Force. **Keith Draycott**



TYPE	NORTHROP	CANADA	SWITZERLAND	KOREA	TAIWAN	SPAIN
F-5A	624	89 (CF-5A) 75 (NF-5A)				18 (SF-5A)
RF-5A	89					18 (SRF-5A)
F-5B	200	26 (CF-5D) 30 (NF-5B)				34 (SF-5B)
F-5C						
F-5E	792		85	48 (KF-5E)	242	
RF-5E	12					
F-5F	146		6	20 (KF-5F)	66	
T-38A/ AT-38B/ T-38C	1139 T-38A built with 50 other versions. 562 T-38A/AT-38B upgraded to T-38C					

A Northrop F-5 Tigre III of the Chilean Air Force. **Chris Lofting**

CANADA

Canadair built the F-5 under licence for the Canadian Armed Forces, the first aircraft being delivered on November 5, 1968. These aircraft were redesignated CF-5A for the single seat fighters and CF-5D for the two seat aircraft, equivalent to the F-5A and F-5B respectively. A total of 89 CF-5As and 26 CF-5Ds were built, 44 of which were placed in storage due to defence cuts in the early 1970s. Sixteen CF-5As and four CF-5Ds from these stored aircraft were supplied to Venezuela in 1972. In the same year, air-to-air refuelling capability was added to the Canadian aircraft in service.

In 1988, 23 CF-5As and 33 CF-5Ds were upgraded by Bristol Aerospace in Winnipeg, a programme that was to include strengthening of the airframe, rewiring, the addition of a head up display, inertial navigation system, weapons aiming and computing system and a new central computer. The first modified aircraft, a CF-5D, was delivered in August 1989. This initial modification programme was followed in 1990 by an avionics suite upgrade to 36 CF-5s to enable the type to be a more effective lead in trainer to the CF-18s then entering service. Further budget cuts meant that the CF-5 fleet was retired in 1995, only four years after the first upgraded aircraft flew. The aircraft were placed in storage until 1996, when 10 CF-5As and three CF-5Ds were sold to Botswana, followed by three more CF-5As and two CF-5Ds in 2000.

CHILE

Chile purchased 15 F-Es and three F-5Fs, the first being received in March 1974 and delivered to Grupo 7 at Cerro Moreno Air Base. In 1993, Israeli Aircraft Industries began work on an upgrade contact to 14 F-5Es and two F-5Fs. This included new multi-function displays and a head up display as well as upgraded avionics, computers, GPS navigation system and most importantly the powerful Elta EL/M-2032B multi-mode pulse doppler radar. The addition of air-to-air refuelling probes in 1997 increased the capabilities of what were the best equipped F-5s in the world at that point, now known as the F-5 Tigre III. In 2003, the aircraft received another upgrade including a new expanded multi-function display and the ability to fire the Python IV short range and Derby long range missiles. Now known as the Tigre III Plus, 10 of the aircraft were still in service in 2009 but were being steadily replaced by 18 F-16s purchased from the Netherlands.

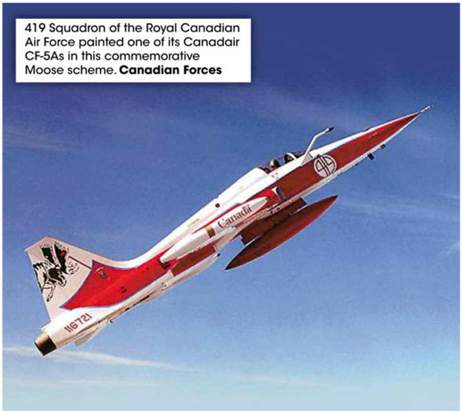
A sideview of a Northrop F-5 Tigre III of the Chilean Air Force. **Keith Draycott**

REPUBLIC OF CHINA (TAIWAN)

The Republic of China Air Force placed its first order for 60 F-5As and Bs in 1963, the first tranche of aircraft from a total requirement of 115 for the type. The first F-5s were delivered in 1964, equipping three squadrons of the 1st Wing at Tainan Air Base. In 1972, 48 Taiwanese F-5s and their associated spares were transferred to the South Vietnamese Air Force in return for the US stationing two squadrons of F-4 Phantoms in Taiwan to maintain air defence, and the supply of 28 T-38s to Taiwan to maintain pilot proficiency while the aircraft were deployed. Twenty of the aircraft sent to Vietnam were returned in 1973, along with 28 additional F-5Es supplied by Northrop in 1975, at which time the F-4 squadrons and the T-38s returned to the US.

The Aerospace Industrial Development Corporation of Taiwan (AIDC) also began producing the F-5E and F under licence in 1974, delivering the first 100 F-5Es by November 1977. Altogether 242 F-5Es and 66 F-5Fs were produced by the AIDC by December 1986, a figure supplemented by the purchase of 45 F-5s from the US in 1979. These 39 F-5Es and six F-5Fs were fitted with wiring for the Hughes AGM-58A Maverick air-to-ground missile and supplied with laser target designator kits, 500 Mavericks and their pylons. In March 1979, 12 undelivered Egyptian F-5Es were deployed to North Yemen at the request of the US with Saudi Arabian support, along with over 80 Taiwanese pilots and groundcrew to operate them. Four Saudi F-5Bs were also made available in support of this operation as continuation trainers for the deployed Taiwanese pilots.

The pilots were recalled in 1991 during the Gulf War as Yemeni allegiances had changed. A programme of upgrades during the 1980s included a self defence aids suite and several of the last aircraft built were modified with enlarged leading edge extensions and the nose from the F-20 Tigershark with its improved aerodynamics. In 1995, seven Taiwanese F-5Es were modified to become photo-reconnaissance RF-5E Tigergazers with a camera nose, the work carried out by Singapore Technologies Aerospace (STAero). Export restrictions on new radars from the US led to Taiwan developing the Tiger 2000 project, covered later in this magazine. From 1997, the AIDC F-CK-1, the F-16 and the Mirage 2000 began replacing the F-5 in Taiwanese service, many being placed in storage as a reserve force, but a number of the F-5Fs and RF-5Es were to continue in service until today.



419 Squadron of the Royal Canadian Air Force painted one of its Canadair CF-5As in this commemorative Moose scheme. **Canadian Forces**

A Northrop F-5F of the Bahrain Amiri Air Force. **Dave Jeffreys**

A pair of Northrop RF-5E Tigergazers of the Republic of China (Taiwan) Air Force on take off. **Kim L Seung**

EGYPT

A deal for 42 F-5Es and eight F-5Fs purchased from the US was brokered by Saudi Arabia for the Egyptian Air Force, and although training for air and ground crew began at McClellan Air Force Base in 1978, the contract was cancelled in 1979.

ETHIOPIA

Ten F-5As and two F-5Bs were delivered to the Ethiopian Air Force in 1966, followed by an additional four F-5As in 1971. Four more F-5As were supplied from Iran in 1974, joined by eight F-5Es from the US in 1975, for the first time with AIM-9B Sidewinder missiles. These aircraft saw action against the Somalian forces attempting to occupy the Ogaden region from 1977 to 1978 claiming a number of air-to-air kills while being flown by both Ethiopian and Israeli pilots. In June 1985, between 10 and 14 Ethiopian aircraft were purchased by Iran to support their F-5 fleet in the face of a US arms embargo on both countries.

GERMANY

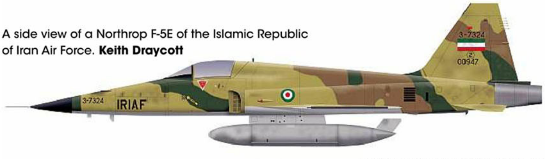
The Luftwaffe uses 35 USAF T-38Cs at its training facility at Sheppard Air Force Base in Texas, where they provide crew training hours for German F-4 Phantom, Tornado and Typhoon crews.

GREECE

Training of Hellenic Air Force air and groundcrew on the F-5 and its systems began at Williams Air Force Base in Arizona toward the end of 1964. Greece would be the first European nation to operate the F-5, receiving 52 F-5As, 16 RF-5As and nine F-5Bs with deliveries beginning in May 1965. One of the F-5As was an ex-USAF aircraft, otherwise they were all brand new. The F-5s were used for air defence in July 1974 during the Cyprus crisis with Turkey. Twelve more F-5As were acquired from Iran in 1974, along with two batches from Jordan, 13 F-5As and eight F-5Bs in 1983, then 13 more F-5As in 1989. ➤

A Northrop F-5F of the Fuerza Aerea Hondureña. **Juan Carlos Cicalesi**

The Islamic Republic of Iran Air Force still operate the Northrop F-5E, seen here coming in to land. **Khashayar Talebzadeh**



A side view of a Northrop F-5E of the Islamic Republic of Iran Air Force. **Keith Draycott**

A Northrop F-5E and F-5F of the Royal Jordanian Air Force. **RJAF**

A Northrop F-5E of the Kenyan Air Force. These aircraft have seen action over Somalia against the Al-Shabab terrorists. **USAF**

A Northrop F-5F of the Republic of Korea Air Force uses its drag chute on landing. **USAF**

One of the two Northrop F-5Fs of the Mexican Air Force in 100th Anniversary commemorative markings. **Ivan Peña**

Norway supplied Greece with nine F-5As in May 1986, followed by 10 Canadair NF-5As and one NF-5B from the Netherlands in 1991. The Canadair built aircraft lacked a commonality of spares with the rest of the Greek F-5 fleet, so were withdrawn from service by 1997. On March 29, 2001, the last F-5s were withdrawn from service with the disbandment of the 343rd Squadron at Mikra Air Base.

HONDURAS

Tensions between Honduras and Nicaragua during the 1980s prompted the Fuerza Aerea Hondureña (Honduran Air Force or FAH) to seek more modern fighters for air defence. A US arms embargo initially blocked their acquisition of the F-5 and later the IAI Kfir C2, but when this was lifted in 1987 10 ex-USAF F-5Es and two F-5Fs were supplied with spares and training for air and ground crew. The F-5s supplemented the Honduran Dassault B.2 Super Mystères in the fighter role until these were withdrawn in 1996. The F-5s were overhauled by Northrop at Palmdale in 1994, but given the return of US arms restrictions to Honduras and after 1996 the aircraft were maintained with the assistance of Chile, but rumours of a transfer of aircraft between the two countries are incorrect. The aircraft still maintain the air defence of Honduras to this day.

INDONESIA

In April 1980 the first of 12 F-5Es and four F-5Fs were supplied to Indonesia to replace ex-Australian Air Force CA-27 Sabres. Eight F-5Es and four F-5Fs were upgraded with improved avionics and radar by SABCA of Belgium from 1995 to increase their commonality with Indonesian F-16s and Hawk trainers and allow the aircraft to act as a lead in fighter trainer for the F-16, the first modified aircraft being delivered in 1999. Although the F-16 is in service there are plans to increase the F-5 fleet. In March 2012 it was announced that both Korea and Taiwan have offered additional F-5s to Indonesia and their current aircraft have sufficient hours to remain in service until at least 2020.

IRAN

The Imperial Iranian Air Force became the first service outside the US to operate the F-5 when it received its first 11 F-5As and two F-5Bs in January 1965 from an order placed the previous year. Altogether 107 F-5As, 13 RF-5As and 20 F-5Bs were delivered by January 1971, although some sources suggest as many as 20 RF-5As were supplied. In 1972, 32 of the F-5As were crated and sent to Vietnam at the request of the US, in return for more F-4E Phantoms being supplied to Iran. With the advent of the F-5E, Iran ordered 141 F-5Es and 28 F-5Fs in February and July 1972, replacing the F-5As as they were delivered from February 1974 onwards.

The Iranian F-5Es had Martin Baker ejection seats, an inertial navigation system and a weapons aiming computer. Many of the F-5As were disposed of to other countries, four to Ethiopia, 12 to Greece, four to

Morocco and 30 F-5As and six F-5Bs to Jordan between 1974 and 1975. Plans to replace the F-5E with the F-16 and F-18 were halted by the Islamic Revolution of 1979. The Islamic Republic of Iran Air Force continued to operate the reliable F-5, with an estimated 45 still being serviceable by October 1985.

The type was used extensively in the Iran-Iraq War of 1980 to 1988 as a fighter and ground attack aircraft. Spares were obtained from sources abroad and from cannibalised airframes, before the Iranian aircraft industry developed the capability to produce parts itself, claiming to be able to build 55% of the aircraft in 1995. Between 10 and 14 F-5s were purchased from Ethiopia in June 1985, but the aircraft were in a poor condition having been stored in the open. It is estimated that five units operate the F-5A, E and F today. Unknown numbers of HESA Azarakhsh and Saeqeh fighters and the HESA Simorgh trainer derived from the F-5 design have been built, probably in small numbers, and are covered later in this magazine.

JORDAN

In 1973 the US agreed to the transfer of 30 F-5As and four F-5Bs from Iran to the Royal Jordanian Air Force in two tranches between December 1974 and September 1975. Two more F-5Bs were also ordered from Northrop in 1973. That same year, it was agreed to supply Jordan with the first of 61 F-5Es and 12 F-5Fs which were delivered from Northrop between 1975 and 1979 replacing the F-104 in service. In January 1989 the first Jordanian F-5E upgraded by Smiths Industries in the UK was delivered, with a new head up display, inertial navigation and targeting system, weapon aiming computer and radar warning receivers were fitted, and the Selenia ALQ-234 ECM pod could be carried.

In this guise, the aircraft was known as the F-5EM, four of which were part of the package of aircraft sold to Brazil in 2007 along with four F-5Es and three F-5Fs. In 1993, it was decided to reduce the Jordanian fleet in order to allow an upgrade of 23 F-5Es with a new radar. To fund this, four F-5Es were to be sold to Indonesia, but this was vetoed by the US. Seven F-5Es were sold to Singapore in 1994, followed by 10 F-5Es, three F-5EMs and two F-5Fs which were sold to Kenya with spares and maintenance and training support in 2008.

The only known remaining Libyan F-5A is this one in the dump at Oki Ben Nafi Air Base. **Chris Lofting**

KENYA

The first order for F-5s was placed by Kenya in 1975 for 10 ex-Iranian aircraft, but this did not go ahead. The following year the US agreed to sell 10 F-5Es and two F-5Fs and deliveries began in March 1978. Two more F-5Es were supplied in 1982 to replace losses. Pilots were trained in the US, taking part in reconnaissance operations over Somalia in 1996. Financial problems affected the maintenance of the aircraft until a team of US engineers were sent to Kenya in 2007 to improve the support infrastructure for the type. Ten F-5Es, three F-5EMs and two F-5Fs which were sold to Kenya by Jordan in 2008, fitted with new avionics and communications equipment from Rockwell Collins. From October 16, 2011, Kenyan F-5Es supported ground forces fighting in Somalia against Al-Shabab terrorists and remain in service today.

REPUBLIC OF KOREA

The largest far eastern user of the F-5, the first batch of aircraft for Korea came under the Military Assistance Programme (MAP), when 88 F-5As and 20 F-5Bs were delivered between 1965 and 1972. Aside from these, a further 16 F-5Bs were purchased directly from Northrop, followed in 1971 by eight RF-5A reconnaissance aircraft. As with other countries, in 1972 the US requested the transfer of 48 F-5As to Vietnam, the loaned aircraft to be replaced by F-5Es. This was changed by Korea to sending 36 F-5As to Vietnam in exchange for the lease of 18 F-4D Phantoms. Korea decided on an expansion of its air force, with the first of 126 F-5Es and 20 F-5Fs being delivered on August 27, 1974.

Of the F-5As sent to Vietnam, 19 were returned in 1975, but by 1989 all the early F-5s had been replaced in service by the newer models, three of the F-5As being sold to the Philippines Air Force. In 1979 the Hanjin Corporation, a division of Korean Air Lines, was ready to begin building aircraft under licence. The F-5 was chosen and 48 KF-5Es and 20 KF-5Fs were ordered, the first KF-5F flying on September 9, 1982. In August 2007, the last F-5As and Bs were retired. The F-5E and F fleet, having undergone a series of avionics and systems upgrades over their service life, are likely to remain with the Korean Air Force for some time. In 2010 174 were still operational, some having been replaced by the KAI F/A-50, F-15K and KF-16. In addition to the F-5 models, in April 1999, Korea leased 30 T-38A trainers which were returned to the US in 2009 with the introduction of the KAI T-50 Golden Eagle.

LIBYA

In May 1967, the Royal Libyan Air Force reached agreement with the US for the purchase of eight F-5As and two F-5Bs. These were all delivered by 1969 when a coup established the Libyan Arab Republic on September 1. The withdrawal of US support for the aircraft meant the Greek Air Force took over training and maintenance support, but a lack of spares limited the aircraft in Libyan service and they were quickly replaced by Mirage IIIs. In 1975, five F-5As and two F-5Bs were transferred to the Turkish Air Force, only one F-5A remaining in Libya in a dump at Oki Ben Nafi Air Base. ➤

Four of the Canadair NF-5Bs of the Royal Netherlands Air Force. **Luigino Caliaro**

A pair of CASA SF-5Ms of the Spanish Air Force at the top of a loop. **Luigino Caliaro**

MALAYSIA

The first deliveries of 14 F-5Es and two F-5Bs to the Royal Malaysian Air Force started in June 1975, followed by three more F-5Fs purchased in 1978, the original F-5Bs being sold to Thailand. Two RF-5Es were also purchased in September 1980 to fill the reconnaissance role. Additional aircraft to replace losses saw three F-5Es and one F-5F being delivered between 1979 and 1985. The last few F-5Es delivered had the F-20 Tigershark nose, but by 2000 the type had been withdrawn from service and placed in operational reserve storage. In 2003, it was announced that three F-5Es, two RF-5Es and two F-5Fs would be returned to service, work which was completed in 2004. Some avionics and camera upgrades were included in the revision work that returned the aircraft to service with 12 Squadron at Butterworth Air Force Base.

MEXICO

Mexican Air Force was supplied with 10 F-5Es and two F-5Fs between August and November 1982. The aircraft have been used for intercepting drug carrying illegal flights over Mexico since their introduction. A GPS navigation system and a longer range version of the AN/APQ-159 radar have been fitted as upgrades. While further upgrades and replacements have been proposed, none as yet have been accepted so the F-5 will remain in service for the foreseeable future.

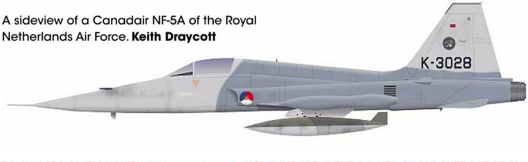
MOROCCO

The Royal Moroccan Air Force took delivery of 17 F-5As, two RF-5As and four F-5Bs between 1966 and 1971. Six more F-5As were supplied by Iran with US agreement in April 1976. The aircraft were used in the Polisario War in Western Sahara between 1976 and 1991, conducting ground attacks against the Polisario Liberation Front. In 1979, 16 F-5Es and four F-5Fs were ordered, these aircraft being equipped with air-to-air refuelling probes and delivered by August 1981. To replace aircraft lost in the war, 10 more ex-USAF F-5Es were purchased in 1989 and the remaining eight F-5As, two RF-5As and two F-5Bs were upgraded to F-5E avionics standard by Sogerma in France. From 2001 to 2004, 24 Moroccan F-5E and Fs were further upgraded by Sogerma and IAI with the FIAR Grifo F Plus radar, ECM pods, radar warning receivers, multifunction and head up displays and a new weapons delivery and navigation system. Known as the F-5E/F Tiger III, the aircraft can now use beyond visual range missiles.

NETHERLANDS

The Royal Netherlands Air Force ordered 75 Canadair CF-5As (NF-5As) and 30 CF-5Bs (NF-5Bs) in 1967, the aircraft being partly built in the Netherlands as part of the deal, the last ones being delivered on March 20, 1973. Upgrades to the aircraft included the addition of chaff and flare dispensers and radar warning receivers, as well as some upgraded avionics. The last of the type were withdrawn from service in March 1991, having been used as fighter bombers and day fighters until replaced by the F-16. Of these, 45 NF-5As and 16 NF-5Bs were purchased by Turkey in 1989, 16 of the single seaters being used as spares airframes. As well as those, 11 NF-5As and one NF-5B went to Greece, the single seaters again being mostly used for spares, and one NF-5A and six NF-5Bs were sold to Venezuela.

A sideview of a Canadair NF-5A of the Royal Netherlands Air Force. **Keith Draycott**



NORWAY

Norway specified its own version of the F-5A for the Royal Norwegian Air Force in an order placed in 1964. This was to have an arrester hook, the ability to use JATO equipment and the ability to fire the Bullpup missile among other detail changes. Known as the F-5A(G) and F-5B(G), 56 single seat and eight two seat aircraft were ordered, deliveries beginning in February 1966. In February 1968, a further 10 F-5A(G)s and two more F-5B(G)s were ordered, as well as 16 RF-5A(G) reconnaissance aircraft.

A new Ferranti lead computing optical sighting system was fitted to the fleet in 1973, but in 1982 cracks in the engine air intakes were found, necessitating a repair programme that grounded 60% of the fleet. A Service Life Extension Programme (SLEP) was carried out between 1984 and 1986 which included corrosion protection and airframe refurbishment. This was followed by the addition of chaff and flare dispensers and radar warning receivers in 1987. In 1991, the cockpits of seven F-5A(G)s and 8 F-5B(G)s were rebuilt to resemble those of the F-16s then in service in Norway, with all the attendant head up and multifunction displays, improved databus and avionics.

As the F-16 was introduced into service, F-5s began to be retired, the first being the RF-5As in 1982, six of which were transferred to Turkey. After this, 25 more Norwegian F-5As went to Turkey, nine to Greece and one was used in the US to build the Grumman X-29A forward swept wing demonstrator. The 15 F-5s with F-16 style cockpits were used to develop the Penguin anti-ship missile, before they too were retired in 2007, five going to maintenance schools, the rest placed in storage.

The Canadair NF-5A and B is the mount of the Turkish Stars, the Turkish national aerobatic team. **Luigino Caliaro**

PHILIPPINES

Between 1965 and 1967, 19 F-5As and three F-5Bs were delivered to the Philippine Air Force. These were followed in 1989 by three ex-Taiwanese F-5As and a single F-5B, numbers further bolstered by what is believed to be eight ex-Korean F-5As and two Jordanian F-5As which were delivered during the 1990s. The aircraft were used against insurgents on Luzon and in the Visayas Islands between 1971 and 1977 in the ground attack role, but they were not involved in the unrest that brought down the Marcos government in 1986.

Several were captured during a military coup in 1989, but were returned when the rebels surrendered in December of that year. By 1990, only eight F-5As and two F-5Bs remained airworthy, taking part in the defence of the Spratly Islands against Chinese interest in 1992 and 1995. The last F-5s were retired on September 30, 2005, at a special ceremony, 15 surviving airframes being stored at Clark and Basa Air Bases.

PORTUGAL

The Portuguese Air Force leased 12 T-38A aircraft from the USAF to replace its trainer fleet, the first six aircraft being delivered in 1977. The aircraft gave reliable service in this role until they were retired in 1993.

SAUDI ARABIA

Altogether, 75 F-5Es, 20 F-5Bs and 24 F-5Fs were delivered to Saudi Arabia between 1972 and 1978, a supply contract that included Northrop setting up training and support centres at Dhahran and Taif Air Bases to enable Saudi Arabia to become completely self-sufficient in its operation of the aircraft. The Saudi F-5Es were well equipped, being fitted with air refuelling probes, chaff and flare dispensers, a radar warning receiver and the ability to carry an ECM pod, not to mention a manual laser designator and a host of other avionics upgrades from new.

JATO capability was provided, as was the ability to carry the AGM-65A Maverick missile and laser guided bombs. The F-5Es replaced the BAC Lightning Mk.53 in the attack and reconnaissance roles. During the Gulf War of 1991, Saudi F-5Es flew close air support and interdiction missions against Iraqi forces in Kuwait, one being lost to ground fire on February 13. Between 1996 and 2001, the F-5Es and Fs were converted to F-5S and T standard by Singapore Technologies Aerospace (STAero). This meant deleting one cannon from the aircraft, in the case of the F-5Fs the only cannon, to make room for a completely new suite of avionics, including the FIAR Grifo F radar and a completely new glass cockpit, databuses, weapons delivery and inertial navigation systems.

The leading edge root extensions were also enlarged to improve manoeuvrability. In 1997, the nine remaining RF-5Es were fitted with a GPS based navigation system by Northrop Grumman, the airframes were also strengthened to extend the service life of the type. Eight of these then received the full STAero upgrade in 1998, being redesignated RF-5S. With the introduction of the F-15, the Tornado and, in 2007, the Typhoon, the F-5 fleet were retired to storage except in the trainer role.

SINGAPORE

The Republic of Singapore ordered 18 F-5Es and three F-5Fs in 1976, the first aircraft being delivered in 1979. Six more F-5Es were purchased in 1980, featuring an extended dorsal fin and wing leading edge extensions as well as the F-20 Tigershark nose, followed by three more F-5Fs in 1982 and another six F-5Es in 1985. The last batch of five F-5Es were delivered in 1989, since the production line had ended, these aircraft were built from Northrop's vast stocks of spare parts. STAero converted eight F-5Es to RF-5E Tigereye reconnaissance aircraft in 1990 and 1991. In 1991, STAero won the contract to upgrade the Saudi Arabian fleet as described above. Following this success in 1994, seven former Jordanian F-5Es were purchased and, along with the existing fleet, converted to the F-5S standard for the Republic of Singapore Air Force, creating 32 F-5Ss, nine F-5Ts and eight RF-5Ss. With the introduction of the F-15S and F-16C into service, three of the F-5 squadrons were re-equipped, but the type will form an important part of Singapore's defences for many years to come. ➤

A Northrop F-5E Tiger III of the Royal Moroccan Air Force during air to air refuelling. **USAF**

A Canadair VF-5A of the Venzuelan Air Force. **Juan Carlos Cicalesi**

SOUTH VIETNAM

As described in detail earlier in this magazine, from 1969 during the Vietnam War, the Vietnam Air Force (VNAF) received 158 former US, Korean, Iranian and Taiwanese F-5A Freedom Fighters, 10 RF-5As and 8 F-5Bs trainers. The F-5As were mostly used in ground attack and close support missions over South Vietnam against insurgent North Vietnamese forces. Later, 55 F-5E Tiger IIs were supplied from the US and equipped two squadrons of the VNAF, but the surrender of April 30, 1975, meant that most of the airworthy F-5s were evacuated to Thailand. A number were captured by the Vietnam People's Army on airfields that had been overrun.

SOVIET UNION

Several F-5Es were received from captured examples in Vietnam and Ethiopia for performance tests and evaluation flights. They were tested in mock combat which helped shape the next generation of Soviet fighters.

SPAIN

CASA of Spain began licence production of the F-5 in 1968, the first nine aircraft being assembled from parts supplied by Northrop, every one after that being completely manufactured at Getafe. These aircraft had their own designations, the 18 fighters on order were known as SF-5As, the 18 reconnaissance aircraft the SRF-5A and the 34 two seat trainers the SF-5B. The first aircraft were handed over to the Spanish Air Force on June 19, 1969, and production was completed in December 1972. In 1990, CASA in cooperation with Bristol Aerospace of Canada carried out a SLEP on 23 of the SF-5Bs, refurbishing and strengthening the wings, fin, lower fuselage and undercarriage, this work being completed in 1995. The SF-5As were all withdrawn from service in 1992, the SRF-5As in 2003.

Just prior to this, the SF-5Bs underwent a two stage modification programme to keep them in service as fighter trainers until 2024. Performed by CASA and IAI, the first part of the upgrade includes a complete avionics suite, new computers, head up display, navigation and communication systems. The 22 new trainers can also carry the AIM-9J version of the Sidewinder and are known as SF-5Ms, the last one being delivered in May 2007. Meanwhile, the second, structural strengthening phase of the upgrade began in 2003, with the first delivery of a fully modified SF-5M taking place in 2005 and the last one expected in 2016.

SUDAN

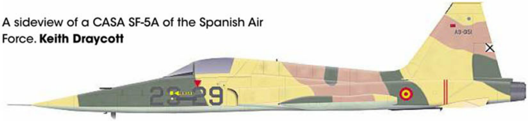
The US agreed to supply the Sudanese Air Force with 10 F-5Es and two F-5Fs in 1980. Only two of the F-5Es were ever delivered, in June 1984, nearly two years after the two F-5Fs which had arrived in October 1982. Both of the F-5Es and one of the F-5Fs were destroyed in crashes between 1984 and 1985 and the remaining F-5F was given to Jordan in exchange for ammunition for the Sudanese Army.

SWITZERLAND

The full story of the production of the F-5 in Switzerland is told elsewhere in this magazine, 98 F-5Es and 12 F-5Fs being built by the Swiss Federal Aircraft Factory in Emmen.

THAILAND

The Royal Thai Air Force received its first F-5As, RF-5As and F-5Bs in 1968 as part of an agreement to allow USAF units to be based in Thailand for operations against Vietnam. These were followed by 34 F-5Es and six F-5Fs delivered between 1977 and 1981, with 10 more F-5Es purchased from the USAF in 1988. In Thai service, the F-5A models are known as the B.Kh.18, the F-5E variants as the B.Kh.18A. In 1985, Thailand began an upgrade programme to 20 of its F-5Es, including a head up display and weapons aiming computer, inertial navigation system, radar warning receiver and chaff and flare dispensers. A further 18 of the F-5Es and Fs were partly upgraded with only the head up display and navigation system. The aircraft were then used for both the fighter and ground attack roles. The F-5As and Bs were all retired by the mid-1990s, leaving a reduced fleet made up of 11 F-5E and Fs that underwent a capability improvement programme in the late 1990s, and 16 of the F-5T Tigris, a much improved version of the aircraft upgraded by IAI. The F-5T Tigris has the Dash helmet mounted cueing system, a glass cockpit, the Elbit EL/M-2032 multimode radar and can be armed with both Python 3 and 4 air-to-air missiles. The F-5Es and Fs were supposed to retire in 2012 with the introduction of the second tranche of Saab Gripens into service, but this has met a financial delay so they are still in service as this is written. The F-5T Tigris is intended to remain in service until between 2015 and 2020.



A sideview of a CASA SF-5A of the Spanish Air Force. **Keith Draycott**

TUNISIA

The Tunisian Air Force ordered eight F-5Es and four F-5Fs in 1981, the last aircraft being delivered in 1984. When the UK based USAF Aggressor unit was closed, five F-5Es were transferred to Tunisia in 1989. Sixteen of these aircraft are still in service today with 15 Squadron at Bizerte-Sidi Ahmed Air Base.

TURKEY

Altogether 241 Northrop F-5s and 73 T-38A Talons have been supplied or purchased by Turkey over the years. In 1964, the first F-5As, RF-5As and F-5Bs were ordered, deliveries beginning the following year. By 1989, 100 F-5As, 57 RF-5As and 22 F-5Bs had been acquired directly from the US, or via the US, or directly from its Allies. Korean, Libyan, Norwegian and Taiwanese F-5s all ended up serving with the Turkish Air Force. To supplement the operational trainer versions, in 1979 the first of 73 T-38A Talons were delivered from the US. In 2007, 66 T-38s were still in service and Turkish Aircraft Industries (TAI) began an avionics modernisation programme to upgrade 55 of them. Called the Ari, or Bee, the upgrade project includes a completely glass cockpit with a head up display, new computers, hands on throttle and stick controls and modern navigation and communications equipment. The first upgraded T-38, known as a T-38M, was delivered in April 2012, the last aircraft should be completed by the end of 2013.

In 1989 as they were being retired by the Royal Netherlands Air Force, 45 NF-5As and 16 NF-5Bs were purchased by Turkey, 16 of the NF-5As being used as spares airframes, not intended to fly. The NF-5As and Bs became the mount of the world famous Turkish Stars national aerobatic team. In 1998 a contract was signed between the Turkish Air Force, IAI, Elbit and STAero to upgrade some of the F-5 fleet to F-5-2000 standards. Altogether 54 F-5s were modified under the programme, 18 F-5As, seven F-5Bs, 18 NF-5As and 11 NF-5Bs. The two part project began with a structural life extension and reinforcement programme, fitting or indeed building new parts where required. Then the aircraft were given a complete avionics and systems upgrade, including a full glass cockpit and head up display. The first F-5B began the upgrade in May 1999, making its first flight on April 17 2001. Only these upgraded aircraft remain in service today, with the Turkish Stars and with a fighter training squadron.

VENEZUELA

In 1969, Venezuela were looking for a replacement for the F-86K Sabre as a front line fighter. Canada had a number of CF-5 airframes in storage that it offered to Venezuela, 16 CF-5As and two CF-5Ds being drawn from stocks, two more CF-5Ds being new build aircraft. The little fighters were redesignated as VF-5As and VF-5Ds, nicknamed Zancudo (mosquito) in Venezuelan service where they were popular and reliable. Two of the VF-5As were modified to be able to carry four cameras a detachable nose to fulfil the daylight reconnaissance role, in which guise they were known as RVF-5As. In 1991 six ex-Netherlands Air Force NF-5Bs and one NF-5A were purchased to replace losses, then, in 1993, STAero was chosen to upgrade 13 single seat and a single two seat aircraft from the fleet. A new mission computer, head up display, air refuelling probe, TACAN, identification friend or foe (IFF) system and chaff and flare dispenser were added, along with a complete airframe and engine overhaul. Today, eight VF-5As and three VF-5Ds are still in service and are pending another upgrade which has been delayed, but will enable them to stay in service for many years.

VIETNAM

Vietnam People's Air Force (VPAF) used over 100 captured examples of the F-5A and E after the Vietnam War. One F-5E, 73-00867, was sent to the Soviet Union for comparative trials against Soviet combat aircraft. The F-5 served in the VPAF for many years despite the lack of spares and support, being a relatively simple and reliable aircraft. In 1979, F-5s supported the invasion of Cambodia by Vietnam, flying close support missions. When China reacted to the invasion with a border war known as the Sino-Vietnamese War, the F-5s flew both air defence and ground attack sorties. A number of F-5s are still on display around Vietnam, in parks and museums.

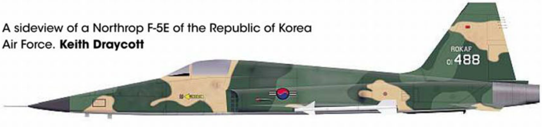
YEMEN

With Saudi Arabian support and at the request of the US, in April 1979 12 F-5Es from the undelivered Egyptian order were sent to North Yemen to provide an air defence force. Saudi Arabia also made four if its F-5B trainers available for continuation training for the pilots deployed on this mission. Over 80 pilots and ground crew were sent from Taiwan to operate the aircraft as there were no jet pilots in North Yemen at the time. The pilots were withdrawn in 1991, a year after Yemen unified, due to their change of allegiances during the Gulf War. The aircraft remained, with a trained cadre of personnel to fly and maintain them. Today it is thought eight F-5Es and three F-5Fs are still airworthy. ■ *Words: Tim Callaway*

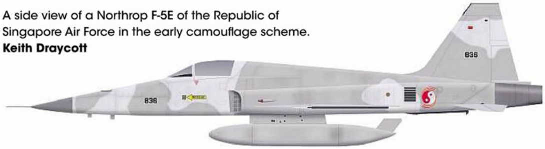
A Northrop F-5F of the Royal Thai Air Force in 30th Anniversary commemorative markings. **Dave Jeffreys**

070 avclassics 019 037 – Four Canadair NF-5As of the Turkish Air Force. This fleet has been upgraded to the F-5-2000 standard. **Luigino Caliaro**

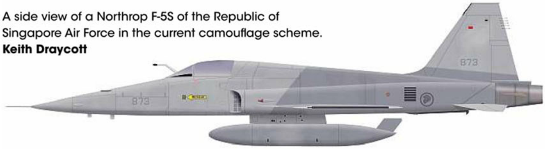
A sideview of a Northrop F-5E of the Republic of Korea Air Force. **Keith Draycott**



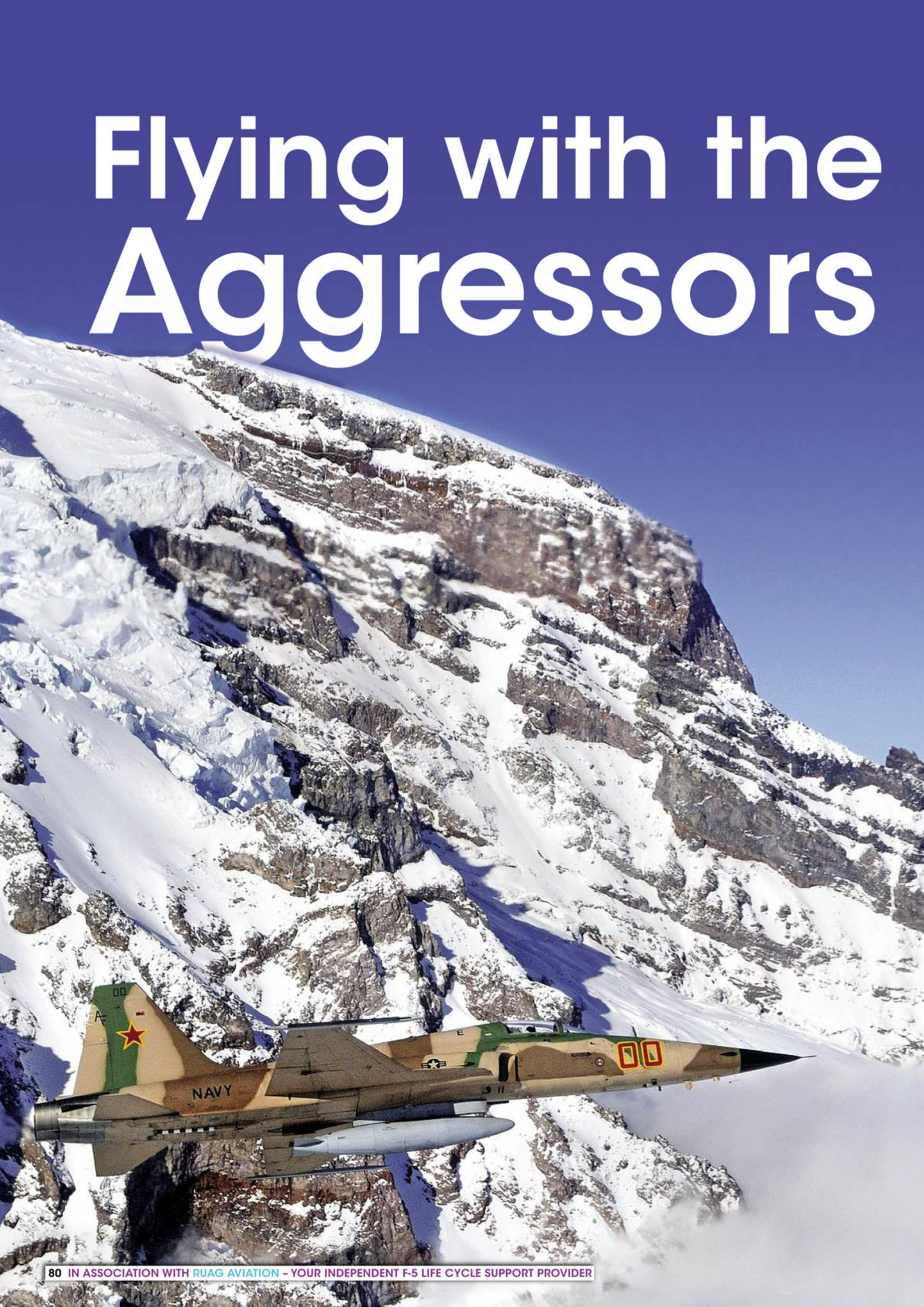
A side view of a Northrop F-5E of the Republic of Singapore Air Force in the early camouflage scheme. **Keith Draycott**



A side view of a Northrop F-5S of the Republic of Singapore Air Force in the current camouflage scheme. **Keith Draycott**



Flying with the Aggressors



The F-5 in the US Navy adversary squadrons

It may have only seen limited combat deployment during the Vietnam War but Northrop's little fighter was soon found new roles by the USAF, the US Navy and the US Marine Corps. The F-5's simplicity and superb handling could be used to emulate the third generation fighters of the Warsaw Pact, many of which are still in service today with countries all over the world. Given its light weight and extreme manoeuverability, the F-5 has become a valuable training tool to sharpen the edge of the front line fighter squadrons.

Aggressor or 'adversary' squadrons deploy aircraft with very different capabilities to those of front line units and combine these with different tactics to create a real air combat challenge. The intent is to accurately simulate the kind of air combat environment pilots may meet in the real world, and thereby teach them how to succeed in it. Front line pilots learn how to use the superior capabilities of their aircraft and systems to defeat more agile but electronically simpler adversaries. Known as Dissimilar Air Combat Training, or DACT, the adversary units teach the front line pilots to stay in those areas of the performance envelope where they have the advantage.

In this section, four airmen with many hours of operating the F-5 in this role with the US Navy talk frankly about their experiences of flying in such a demanding role. One thing becomes clear as you read these accounts: not only is the F-5 well suited to the task, it is also tremendous fun. 'Paco' Chierici, 'Monk' McCormick and 'Buckethead' Cole all talk about flying the F-5 with various units in the US Navy, while 'Bio' Baranek explains the F-5s starring role as the 'MiG-28' in the movie Top Gun and how the combat sequences in that film were made. This is a collection of fascinating insights into the world of the modern fighter, and *Aviation Classics* would like to thank these excellent writers for their time and efforts in producing these exciting and honest accounts. ➤

Two F-5Es of VFC-13 high in the Stillwater Mountains, their camouflage patterns ideal for this kind of terrain. **Jos M Ramos - RamosAviationPhotos.com**

SPEED AND ANGELS

FLYING THE F-5 TIGER II IN THE ROLE IT WAS BORN TO

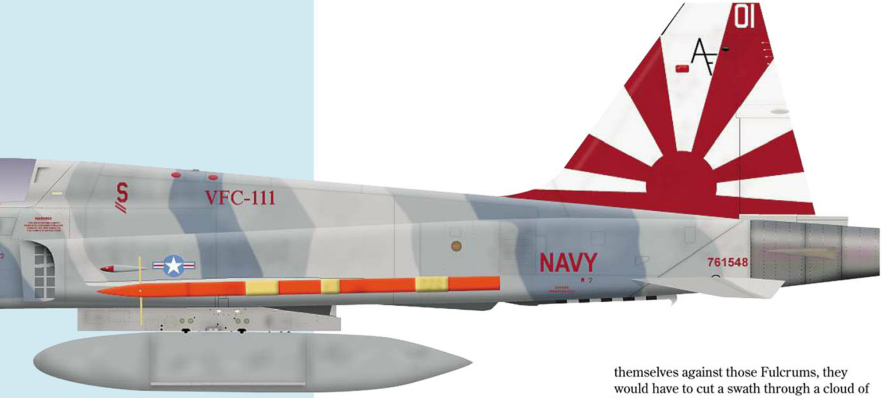
By F A 'Paco' Chierici CDR USNR (retired)

Jorge Canyon, the Centroid, the Six-Pack, Sperm Lake, Circle Squares, the Dong. These are the inside names of some of the secret hiding spots in the greatest aerial playground in the United States. For 10 years I was fortunate enough to be a member of a squadron flying the F-5 Tiger II as an adversary pilot, or bandit, with VFC-13 in Fallon, Nevada. For a pilot who loves flying (and there's a shameful number who don't), the convergence of the last real 'stick-and-rudder' fighter in the US inventory; a vast swath of airspace to patrol (surface to stratosphere), and a squadron of like-minded ACM junkies; this is the place bad boys pray to end up when they go to heaven.

I was a reservist in this squadron and thus had the benefit of perspective, having already given up flying a magnificent flying machine, the F-14 Tomcat. I knew that every flight was a gift, every dogfight a treasure, every merge one step closer to the day when Peter Pan would have to leave and grow up. With just a few years remaining for me to fly the F-5, I realised that I wanted to preserve the moment for as long as possible. To distill it as I was experiencing it so that I could dip into it in the years of ordinary life and take a sip. I decided that I wanted to tell the story of this world in a visual way. I enlisted a spectacular director, wrangled some cash from enterprising investors and the result three years later was an award-winning documentary about the spirit and adventure of Naval Aviation, Speed and Angels. It is an unvarnished, full throttle, pulse pounding peek into the heart of flying fighters for the US Navy told through the eyes of two young aviators. But the genesis of the film had always been the concentrated passion for air combat that we enjoyed flying F-5s in Fallon.

The F-5E was a peculiar bird (VFC-13 currently flies F-5Ns, most of which were procured after 2006 from Switzerland). It was tiny for a fighter, especially one with two engines. It had no modern systems, unless you consider hydraulics to be modern. No anti-skid. No INS nor GPS. No HUD. Just a simple old-fashioned pulse radar and a basic gunsight. It had no defensive systems, no RWR nor expendable countermeasures, other than the fact that when pointed nose-on to an adversary it completely disappeared, like a cloaking device being activated.

There was no sophisticated technology required to enable the disappearing act, just the fact that the pilot sat in a cramped little cockpit on the head of a needle with tiny, razor thin wings behind him. And when that needle was nose on to a Tomcat or Hornet pilot who had lost radar lock or situational awareness, his skin would crawl and the hairs on the back of his neck would bristle. Because he knew that the very next time he was sure of where the bandit was, was likely to be when he heard the dreaded: "Trigger down, tracking, tracking…" It was a plane perfectly suited to the role of adversary; fast, simple, nimble, eminently beatable by a competently



Above: This side view is one of the F-5Ns of Composite Fighter Squadron 111 (VFC-111), the Sundowners and wears the famous insignia on the tail. This is the East Coast Adversary Squadron based at Naval Air Station Key West in Florida. VFC-111 has 18 Northrop F-5N/F Tiger-IIs, of which 17 are single-seater F-5Ns

Below: An all black F-5F of VFC-13, the Saints. The special paint schemes was to commemorate the 100th anniversary of naval aviation. **Keith Draycott**

flown front-line fighter; but capable of pouncing on an error and creating a learning point in the form of a simulated kill. If you lost to the F-5, you had something to learn, and that's the way it should be.

It's often mentioned that the F-5 is used as an adversary because it is a perfect simulator for the MiG-21, and it's true, the V-n diagrams superimposed show almost identical manoeuvring performance characteristics. That is a great serendipity but in truth it would have been a perfect adversary platform regardless. VFC-13 models its presentations to what is known as the 'percentage threat', the most likely global scenario for our fighters to face in combat. Think North Korea. Lots and lots of small, fast, simple enemy fighters swarming the technologically superior but numerically challenged navy forces. Topgun, which is across the street on NAS Fallon at the Naval Strike and Air Warfare Center, specialises in teaching the skills needed to defeat the more modern threat aircraft. To this end, Topgun flies the F-16 and F/A-18. Fantastic, superior platforms that can superbly simulate MiG-29s and Su-27s. Instead VFC-13, call sign The Saints, specialises in the Stalinist principle of 'quantity has a quality all its own'. North Korea operates more than 400 third generation fighters and only 35 MiG-29s. Before any US Navy pilots would get to test themselves against those Fulcrums, they would have to cut a swath through a cloud of MiG-21 and 23s.

For a reservist who flew no more than 120 hours per year, 0.8 at a time, the F-5 was a dream. It was inexpensive to operate, therefore plentiful; and painfully simple, thus always mission ready. We flew as much as we could stand, often against each other to maintain tactical proficiency and to sharpen the dogfighting skills which we held in such high regard. One of the most dramatic differences between fleet pilots and VFC-13 pilots is the amount of time devoted to basic fighter manoeuvres (BFM), both in the air and in the briefing room. Coming from the F-14 community I felt I had a pretty good grasp of BFM fundamentals. But a bandit pilot lives and breathes air combat. There are none of the distractions that a fleet pilot must deal with like air-to-ground, CAS, LATT, SES and much more. It is pure air-to-air, with an emphasis on close-in manoeuvring.

New adversary pilots, many with 1500 hours or more, are greeted with a demanding syllabus in graduate level air combat that takes at least a year to complete, despite having fewer than 20 graded hops. The meticulousness, precision and professionalism required to represent the squadron as a fully qualified bandit means that there will be many a refly. Often one particularly onerous event can be reflown a number of times before the aspiring bandit meets the standards required to move to the next sortie. It's a humbling and sometimes frustrating year. But coming out ➤

Cooch on the tip of a loose cruise of Tigers. **Chad Mingo**

A section of bandits taking Runway 13R at NAS Fallon. Note the primitive gunsight and strap-on GPS. **Chad Mingo** the other side is a finely honed, meat-eating BFM machine. A Shaolin monk of aerial hand-to-hand combat, broken down and rebuilt without the distractions of advanced radars and electronic crutches.

When you are one of the Saints, you use all of your senses to build situational awareness, you use the earth and the sun as your allies, you use the simple tools at your disposal to maximum effect. And when you have completed your task, you have sacrificed yourself for the good of your student imparting as much of your wisdom as possible through lessons of quiet victory.

When it comes to aerial presentations, the Saints give their students two basic types; beyond visual range (BVR) scenarios with multiple groups of bandits which challenge the fighter's ability to effectively target and manoeuvre as part of a team; and BFM. BFM is the skill required to manoeuvre against and destroy a bandit in the visual arena. It is a skill that has been kicked to the curb by aircraft designers and war planners since the conclusion of the Second World War yet grudgingly refuses to die in the real world of aerial warfare.

There are a variety of reasons why a modern fighter, bristling with data links, AESA radar, active missiles and HMCSs will find itself pulling max G and dumping flares against an actual enemy fighter across the turn circle. Sophisticated jamming systems are relatively inexpensive and surprisingly capable, rules of engagement (ROE) frequently demand the blue fighter – the good guy – must put itself inside the ranges of infrared (IR) missiles to confirm the identity of a bogey, and most likely, in the era of self-escort strikers, there is a very real chance that they will have to fight their way out of country with a limited air-to-air load because their hardpoints were laden with ordnance designed to move dirt and pulverize cement. In any event, despite the belief to the contrary, it is highly likely that a blue fighter will find itself turning in the visual arena in any future conflict.

The desert camouflage scheme is particularly effective in the terrain around Fallon as shown off by this F-5E of VFC-13. **Jos M Ramos - RamosAviationPhotos.com**

"AN F-5 AGAINST AN F/A-18 IS NOT A FAIR FIGHT. THE HORNET HAS A SPECTACULAR RADAR WITH EXTREMELY CAPABLE AIR COMBAT MANOEUVRING (ACM) MODES."

An F-5 against an F/A-18 is not a fair fight. The Hornet has a spectacular radar with extremely capable air combat manoeuvring (ACM) modes. At 'fight's on' a pilot has just to flick his radar to vertical acquisition mode (VACQ), select his AMRAAM missiles, put lift-vector on and pull until he gets a SHOOT cue. "Kill… knock it off." The Super Hornet has an even more capable ACM suite when the Helmet-Mounted Cueing System (HMCS) is paired with the amazing AIM-9X missile. The ability to slew the AIM-9's seeker head to the pilot's line of sight at ridiculous off-boresight angles is an inescapably lethal combination. By comparison the F-5 has no radar missile.

The Saints use only an IR seeker head and a restrictive envelope from the 1970s limited to a few degrees off boresight. And the dreaded guns. There is no known countermeasure that can distract 30mm rounds. To build a fighter plane without a gun is as foolhardy as sending an infantry soldier into battle without a knife. The only time he will miss it is when he desperately needs it. The navy version of the Vietnam-era F-4 Phantom II didn't have a gun, and it was sorely lacking. Ignoring the wisdom that past is prologue, the navy variant of the F-35 again will not have an internal gun.

In any event, because of this advantage in armament and capability, the majority of engagements end quickly with a decisive victory for the Hornet. Especially after the first or second engagement, once the rust and jitters have been shaken off. But with a few real-world limitations put on a Hornet to limit his first-shot kill ability, the fight becomes far more balanced. Scenarios in which the fighter is placed in a defensive perch or is limited to an off-target weapons load force the Hornet pilot to consider follow-on engaged manoeuvring. The longer an F/A-18 is tied up in a dogfight with an F-5, the higher the chances that he will lose sight or commit a BFM error, and when either of those occur, the advantage tilts rapidly in favour of the bandit. The real-world corollary is the off target strike-fighter, momentarily blind to the air-to-air picture after the drop, caught unawares by a MiG-21. Suddenly defensive, turning for his life and scrambling to take advantage of his superior platform. With every second he delays in splashing the MiG, or bugging out, his risks increase exponentially.

There was a huge amount of satisfaction derived from providing the students with

End of another sortie. Two pilots of the Saints walk back in from the ramp at Fallon. **Sean Connelley**

F-5E flown by the author on short final for Runway 31L at NAS Fallon. **Sean Connelley**

valuable, challenging, realistic training. But as fun as the engagements themselves were, they were always tainted. Either the blue fighter was sufficiently skilled that the engagements were clinical and perfunctory, or the students made enough errors to lose, and that wasn't the goal. The supreme pleasure was in fighting in-house – the 1v1 and 2v1 engagements that we flew against each other. An in-house BFM sortie between two seasoned pilots would consist of a short brief, a quick candy bar and a walk from the ready room 20 to 30 minutes before takeoff. Once airborne off of Runway 31 it was a quick right 90° turn, a push into combat spread and a climb. Two or three minutes later, after crossing over high terrain into Dixie Valley, there would be a G-warm, "Vipers ninety left… resume… Viper One FENCEd." A quick TAC left and a short climb up to 16,000 and it was time for 'fight's on'. With two skilled pilots the engagements would last two, three, sometimes four minutes if taken all the way to a kill, an eternity for a dogfight in the jet age. But the dance is nuanced at this level, even more so with the limitations of the basic weapons systems. In fact during the in-house events, most of the best pilots would limit themselves to what we referred to as a knife fight, guns kills only.

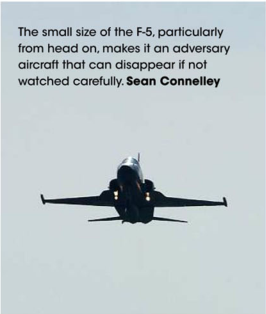
There is no arguing the victor when one plane is saddled behind the other with his pipper on the cockpit. I flew hundreds, if not thousands of these engagements in the years I spent in Fallon, and I remember them all fondly. Even the ones where I was stuck looking over my shoulder like a PEZ dispenser, which happened more often than I would have liked. Most in-house hops consisted of three, or rarely four, intense high-aspect abeam or butterfly starts. Once BINGO was reached and the bandits FENCEd out, it was a quick RTB for the 600 knot carrier break. The most intense, action-packed 0.7 you could ever put into your log book.

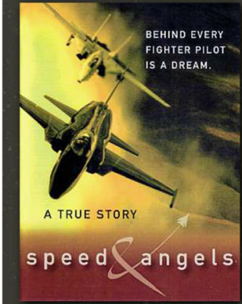
I was fortunate enough to fly with some truly amazing aviators. And now, long after the fact, I still have detailed memories of some of the fights as if they happened just hours ago. I can still see Bat Masterson's jet gaining 10° to 15° on me with each merge and feel the wonder and frustration of flying the machine as best I could, yet realising that in a matter of two or three more merges I was going to be practicing my Last Ditch Guns-D. Bat, a small man with a large moustache, taught me one of my most enduring BFM lessons. In the debrief I petitioned his expertise: "How the ➤

A flight of two F-5E Tiger IIs over Pyramid Lake in Nevada. **Sean Connelley** hell did you do that every engagement? I was fighting as hard as I could." A man of few words, he answered simply: "When you're fast, be fast. When you're slow, be slow." Believe it or not, that bit of wisdom taught me more about fighting the F-5 than the countless losses I had suffered through previously.

I can close my eyes and picture chasing Kemo Percival through a very offensive rolling scissors only to have him execute the most perfect pirouette and pass me 180 out, neutralized, with my jaw hanging open. If this had happened just once, I would have chalked it up to an accident of aerodynamics. But time and again I watched as a rare offensive position was eliminated by this impossible escape. When flying by myself, I would practice over and over; 45-60º nose high, 220-180 knots, full aileron deflection, full opposite rudder, stick first full aft then quickly to full forward. When Kemo did it, his plane rotated horizontally, swapping ends in a blink while still maintaining enough energy to continue flying and fighting. When I tried it, following his recipe to the letter, I ended up either mushing through a reversal of direction but completely without airspeed, or rolling sideways and pulling through a slow speed wingover. No help at all.

And finally, I'll never forget a late afternoon fight against Monty Montgomery in planes that were laden with external tanks. The positive was that we had 1000lb of extra gas, which doubled our number of engagements. The negative was that the F-5 handled like a pig at high Alpha burdened by the effect of the 150 gallon tank. We fought six times with the blood red Sierra Mountains as a backdrop, each a decisive victory, three of which were Monty's. They were, each and every one of them, amazing duels. Filled with feigns and deception, flying at the very edge of the envelope, cautious and cunning. But neither pilot was to be satisfied with a neutral Lufbery on the deck. Chances were taken, and BFM errors made, and each time an opening was given, the opponent was able to capitalize. This was one of the most pure and well flown hops I ever experienced. Two fairly matched pilots in like aircraft using every bit of experience and trickery at their disposal. The knowledge that it would take only one error to seal one's fate, added to the challenge of flying at the maximum limits of performance with the additional load of an external tank, and the race to complete before sunset added to the intensity.


The small size of the F-5, particularly from head on, makes it an adversary aircraft that can disappear if not watched carefully. **Sean Connelley**


BEHIND EVERY FIGHTER PILOT IS A DREAM.
A TRUE STORY
speed&angels

The cover of the Speed and Angels DVD, produced by Cdr. F.A. "Paco" Cheirici USNR (Retd), one of the pilots who wrote this article. The multi-award winning film follows the story of two US Navy fighter pilots during their training, and shows the work of the Saints, VFC-13, in their adversary role. This film is a must for any serious aviation enthusiast, the trailer can be seen as part of the electronic version of this magazine and you can learn more at www.speedandangels.com

The F-5 was the enabler of this amazing flying club. It was a link between the pure era of fighting machines to the modern age of digital combat. The plane was essentially a jet powered P-51 Mustang. And those days you flew it well, you were really flying well. Cables linked the stick to the ailerons and elevator. Dancing on the pedals directly affected the movement of the rudders. When you flew it well you felt the plane speak to you through the whisper of the wind over the canopy and the Bernoullis nibbling at the wing. It was a plane with a reputation for biting the unwary, often with disastrous consequences. But if you respected it, and knew it well, and listened when it spoke, it was a plane that would reward the pilot by exceeding its expectations.

I once matched an F-14D through a double-Immelman, though at the top I was desperately stirring the pot clawing for purchase. But the Tomcat driver was so unnerved that he was off his game for the rest of the fight. It was in this way that the F-5 actualized its mission. It was a pilot's machine that rewarded its devotees and it was a perfect foil for testing the overconfidence of blue pilots in their advanced platforms.

Saint Adversary pilot, Rock, leads a Luftwaffe MiG-29 Fulcrum back from a 1v1 engagement. NAS Key West and a bucket of cold beers await in the background. **Craig Dugan**

The F-5N carries forward that tradition today and for the foreseeable future with some significant enhancements. It sports RWR and chaff dispensers and it has the capability to carry a jamming pod. But the newer lot Rhino is no Classic Hornet or Tomcat. The ability of the F-5 to continue to provide a credible opposition in the face of AESA and AIM-9X is diminishing. The challenge in the future for VFC-13 will be to match the evolving 'Percentage Threat' in the world. Over 11,000 MiG-21s alone have been produced. There are three companies which specialize in upgrading the airframe to modern capabilities. A radar, HUD, data link, active-missiles, high off-boresight IR missiles and effective RWR can all be strapped into a Fishbed for a fraction of the cost of a new fighter and provide almost all of the capabilities. If the Saints hope to continue flying the F-5 and providing realistic training, efforts in this direction will have to be made.

As for me, I will always be grateful for my years as a member of the bandits. They were (and are) a bad ass bunch of dogfighting ninjas. It was an honour to walk with them and learn from them. And share a drink and a laugh. Likewise, the F-5 will forever be under my skin, an integral part of the story of that time. It infected my dreams and dominated my imagination. I obsessed over perfecting it. Of absorbing from my peers how to cajole every last knot and degree-per-second. I will miss flying it, with them, every day for as long as I live. ■

GOOD IS NOT ENOUGH

By Captain John 'Buckethead' Cole, USN (retired)

Sometimes life takes a major twist and puts you on a path not foreseen. Such was the case when I first showed up at Naval Air Station Fallon, Nevada.

I broke my neck flying Tomcats off the carrier in 1988… 18 months later with a fused neck and a USN limitation prohibiting me from flying off and on the boat, I reported to VFA-127, home of the Desert Bogeys.

The squadron flew a mixture of aircraft over two type model series: F-5E/F Tiger IIs and A-4E/F and TA-4J Douglas Skyhawks. We deployed/detached all over North America. We sent pilots to support the Mexican Air Force when they desired to start a dissimilar adversary program (failed attempt); MCAS Yuma in support of MAWTS, Marine Aviation Weapons and Tactics Squadron; NAS Key West in support of nugget training of the Fleet Replacement Squadrons; Cold Lake Canada, home of the 410 Tactical Fighter Operational Training Squadron, the 'Cougars'; and NAS Oceana for Fleet Fighter Advanced Readiness Program, graduate level fighter training later to become SFARP when fighters became strike fighters.

I flew for VFA-127 for three years and then transferred back east to VFC-12, home of the OMARS and did it all over again, plus adding the Hornet to my adversary repertoire. This career path continued over my next five Navy Permanent Change of Station moves.

The adversary squadrons I was in supported the USN, USMC, CVWs, WTI, Red Flags, Green Flags, missile shoots, chased cruise missiles launched from US submarines, towed targets, banners and darts, the air force and the army.

I joined the military in 1981, the Marine Corps to be exact, and retired from the navy in January of 2012 with over 30 years of service. I started flying adversary aircraft June of 1989 and didn't stop for 15 years until April of 2004. It was by far the most enjoyable and rewarding time of my career.

Paco, Sir Buckethead, Grinder and Gooch, preparing for a multi-plane bandit sortie in the Saints ready room. **Sean Connelley**

My first adversary aircraft was the F-5E and my last adversary aircraft was the F-5E so I have a fond place in my heart for this aircraft. Some operator perspectives on the Tiger, in no particular order:

1. Fastest aircraft out of the line. Under two minutes from finger wag to chock pull and taxi. A dream machine for simplicity of use.

2. Worst ejection seat I ever sat in with just one exception (A-4E) and I only sat in that aircraft for about 20 hours of flight time. The F-5 had a chute you dragged out to the airplane, leaned into the seat and climbed in on top of and strapped around you. Horrible design, major ground ejection limitations, especially not zero-zero, which is the fleet standard.

3. Coolest multiplane go's (take offs) around. Like a bunch of bottle rockets in a soda can. Let 'em roll. You could put four side by side on the runway… if you had parallel runways that's eight aircraft.

4. Best force multiplier around. If you flew them, they stayed up. Their sortie generation rate for a 1970s aircraft was/is on par with a new aircraft straight off the manufacturing line. Here is a typical year for scheduling back in 2004:

VFC-east: 1700 SORTIES (F/A-18)
VFC-west: 5100 SORTIES (F-5)

5. If you can see it you can reach out and touch it. We could see F/A-18s... fast, fast, fast aircraft. Loved to go supersonic even demonstrated some super cruise in a mild descent (non-after burning).

6. Small radar cross section (RCS) made this aircraft hard to paint, sort and track by the blue forces. Not impossible, just hard. Also dangerous for the adversary pilot because...

7. Hardest aircraft built to keep track of in a visual engagement. If the F5 goes nose on, it just disappears. Have to keep the head on the swivel, keep track of both the red and blue forces, minimize midair potentials... because the good guys just don't see you.

8. Great cross country aircraft: short, fast ➤

The author, Captain 'Buckethead' Cole, commanding officer of the Fighting Saints. **Sean Connelley**

Geno, signaling ready for engine start. He'll be ready to taxi in under five minutes. **Sean Connelley**

flight times around 0.92 IMN; easy to gas; easy to start up and get on your way.

9. Best intimidating aircraft across the circle in a dogfight. A fuselage-loaded aircraft that could threaten everyone with its ability to keep its pitch axis on you, but no stab authority to get the nose up and actually shoot. It was all bluff – but blue forces fell for it.

10. Coolest paint jobs on the planet. In Fallon, I think we had nine different paint schemes spread out over 26 airframes. From 2003 to 2007 the F-5 was the only growth industry of all tactical jet aircraft programs in the Department of the Navy. Not only did we stand up a new site in Key West at the Naval Air Station, but we also replaced all of our legacy F-5E/Fs with low-hour versions procured from Switzerland and almost no cost. Well, they were around $1.5 million each, but we used the money slated to keep the legacy airframes supported and airborne, so we actually found a better use of the taxpayer dollar and came in under budget with newer, lower FLE (fatigue life expended) airframes to support our deploying, tip of the spear forces.

I had a great career, and I had the usual ups and downs of life thrown my way, but the F-5 was always far and above an up. The folks who supported, a mostly civilian contract tech force; the pilots who flew, a dedicated instructor cadre without peer; and most importantly the naval aviators we trained all benefited from the relationship. The pride and satisfaction demonstrated in maintaining, crewing and training with the F-5 are easily demonstrated when our naval forces go feet dry in bad guy country at '0 dark thirty…'

My story is from my last year as commanding officer of VFC-13, the Saints, the current Adversary squadron stationed at NAS Fallon. When you are a full up round capable of planning, briefing and leading large dissimilar air combat training missions, you will have had the prime mantra of your inherent adversary mission drilled into your head. This mantra is not the mission/scenario at hand, this mantra is not to be King Kong on the training ranges, this mantra is and will always be guardianship of the training rules.

Adversary pilot Geno, walking to his fighter. **Sean Connelley**

But sometimes, when your operational risk management is on the student, you forget to apply it to yourself…

The day started no different from any other, brief was at '0 dark thirty', read sometime around 5am. Double cycle bogey brief in support of the current Topgun class. I was lucky and was currently qualified in both the FA-18 Hornet and the F-5E/F Tiger II, the aircraft flown by my squadron the Saints, whereas I was a guest player flying or borrowing a Hornet from NSAWC, Naval Strike and Air Warfare Center, home to commands like Strike University and Topgun.

That day I was scheduled to fly wing off a Topgun instructor in two Hornets with two additional Tiger IIs completing the Bogey line-up.

Brief, admin, walk man-up and launch all went smoothly. Weather in the area was broken at around 3000ft above ground level (AGL). Fighters launched first to the eastern edge of the military operations area (MOA).

The red air force Hornets were positioned over B17, their designated CAP for the double cycle mission (same mission done twice for two different students).

Presentations by the red air forces were fairly basic this day. We had two runs scheduled per cycle, one in range and one in azimuth. To this end we purposely positioned the F-5s further north in the same valley that leads to B17… north and west of Mount Augusta… Fighter CAP was well east and north of Austin… roughly 60 plus mile run. Once on the range the observed weather was acceptable for tactical training with all intercepts and training occurring above a cloud deck.

All MOA mountain ranges Stillwater, Clan Alpines, Shoshone and Toyabes run roughly north to south and are great visual aids for range SA… today was no different with the ranges all above the cloud deck… white clouds, black/brown spins, blue skies – a perfect day for some training.

After a couple uneventful runs several things occurred simultaneously. One of the F-5s was getting low on fuel and secondly we had reports of lake effect snow moving unforecasted north towards NAS Fallon. This occurs rarely as winter wind patterns are generally from the north, but Walker lake snow in travelling north has a basically clear path through B20 to Navy Fallon. I decided to contact approach for a weather update and

Paco and his wingman, Grinder, taxiing for an in-house dogfight sortie. **Sean Connelley**

Captain Buckethead Cole returning from slaying Blue Fighters. **Sean Connelley**

then passed it over the primary radio. At the time Navy Fallon was still accepting overhead traffic, but it was time to send the low fuel state F-5 home.

After further discussions within our flight, we reached a decision, pretty simple, send home the both F-5s, then the first cycle of blue air Hornets, cancel the second half of the double cycle and then we (myself and my lead) would return to base (RTB) last.

On the recent run the F-5s had only one kill removal, so they were separated from each other by 30 miles. To save gas and time they were going to RTB as singles. Thirty minutes later my lead and I left our CAP switched up Desert control and headed home. Checking in with NSAWC duty officer we found that the earlier events were all on deck, the flight schedule was scrubbed and it was snowing heavily at Fallon. There was no word on the F-5s but the assumption was they had landed before the student Hornets.

Weather had drastically dropped and as we switched from desert to approach we heard a controller giving vectors and a frequency change to one of the F-5s. This was not good – that aircraft should have already been on deck. Not only is the F-5 fuel limited in bingo ranges but it also completely sucks in instrument meteorological conditions (IMC). It is a visual meteorological conditions (VMC) flying machine and a vertigo inducing instrument aircraft. It requires focused discipline to fly on instruments, all due to an off centre attitude indicator and real need for the pilot to minimize head movement when in or transitioning to a IFR scan.

However our flight had its own issues. Weather at the field was now at minimums requiring ground control approaches (GCA) direction to final and to make matters worse, the errant F-5 for some reason, now well south of the field, was now going to be sequenced in behind our flight. Both us and the F-5 were up approach control, being vectored to final and an additional radio switch to a dedicated precision approach controller.

Approach vectored the F-5 who was currently VMC heading 239 at 15,600ft MSL above mean sea level (MSL) left to 150 coupled with an IFR descent to 7500ft MSL. Terrain elevation roughly 4000ft. The F-5 accurately read back his current clearance into Navy Fallon's controlled airspace. In the meantime we were in a right hand turn to 310 base leg and preparing to dirty up… flight would be flown dirty at ½ flaps to a full stop section landing in the snow.

At this time, prior to being switched final, approach had noticed the F-5's radar track below assigned altitude and in a coast mode. Current controller queried the F-5 several times, each time by tone and inflection sounding more anxious than the last until the senior supervisor relieved the controller of the radio and gave our flight a late call vector to final, a dirty up signal and a radio frequency change to final approach. Both my lead and myself were very aware of what had occurred to the F-5. We didn't think he'd gone NORDO (flying with his radio off) nor missed a comm check… the controller's tone was enough for both of us to know the aircraft was now no longer on the radar.

There was nothing either of us could do. We were flying a section approach in zero visibility over mountainous terrain with a controller who may or may not be completely focused on our approach due to the ongoing emergency nature now occurring in the control room. That said, both of us were completely focused on not being mishap number two for the day's flight. My lead flew a flawless approach and my hats off to him. As CO of the F-5 squadron my focus had to be recaged several times during the terminal phase of this flight as I was already in thought shifting to the hundreds of immediate action efforts now being implemented.

We broke out at minimums and made an uneventful if slushy section landing and rollout at the field, cleared the runway, taxied back to the line shutdown and climbed out. I was met by the Naval Strike and Air Warfare Center (NSAWC) duty officer in a vehicle and was driven back to my hangar where the worst was confirmed, both the F-5 and its pilot were un-accounted for and search and rescue (SAR) would have to wait to launch due to the current weather conditions.

Several hours later in clear skies both the aircraft and pilot were found 10.5 miles south of the field.

Although the actual scenario will never be known, the investigation concluded that the F-5 initiated an IFR descent with inadequate IFR scan, resulting in an over aggressive penetration and an unusual attitude in IFR conditions resulting in spatial disorientation and incorrect application of flight controls. On radar the rate of descent increased from 3000 feet per second to over 17000 feet per second and a reversal in heading opposite from controller direction resulting in controlled flight into terrain (CFIT).

This pilot was a seasoned professional, a Gulf War veteran successfully flying off carriers day and night. He is missed today just as much as he was nine years ago. Tactical aviation is a dangerous and unforgiving profession flown by professionals just as dangerous as their aircraft and environment. Avoidable, yes. To be repeated, sadly yes. Nothing's ever perfect and in fact perfect is often the enemy of good… but sometimes good is just not enough. ■

Low and fast, the lakes and valleys of the Fallon area make idea hiding places for the F-5Es of VFC-13. **Jos M Ramos - RamosAviationPhotos.com**

A vic of three F-5Es of VFC-13 high over Nevada. **Jos M Ramos - RamosAviationPhotos.com**

TIGER MANIA

By Glenn 'Monk' McCormick

It's been 25 years since I've grabbed a parachute from the paraloft and strolled out to climb in my F-5. And stroll I did. It is peculiar that the point at which a pilot has to start moving to make a launch time has a particular term. In the air force they have 'step time', in the navy it is call 'walking' – but I definitely strolled to my Tiger. Perhaps it was me, but I did want to visually absorb that sportscar of a fighter.

We were members of the VF-126 Bandits, the 'other' adversary squadron at NAS Miramar in San Diego – perhaps you've heard of Topgun, our more well-known colleagues. The three F-5Es gracing the squadron's Tarmac were cherished by the few of us trained to fly them. We also had one T-38 Talon assigned to us. It had similar systems to those of the F-5, and was mostly used as a familiarisation trainer for those chosen to fly the Tiger. The hardest thing for a navy guy to get used to about both aircraft was how simple they were. Once we accepted the fact that one had to carry the parachute to the cockpit, and how to strap into the seat, then the rest was extremely easy.

More than one Air Force guy, having to learn how to fly the navy A-4 Skyhawk, would declaim the fact that he would have to actually 'turn on' the oxygen to his facemask, usually discovering that particular important point after they attempted to suck dry their mask and turned blue in the process... for some reason perhaps that point was good-naturedly forgotten in the preflight brief. They had it rougher!

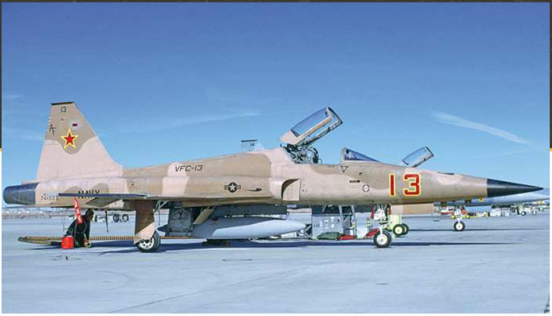
In fact, a new F-5 pilot, going out on his first solo ride in the airplane, after two dual flights in the T-38, would invariably stay in the flightline for an inordinate amount of time with the engines running. When asked why, the answer was always "I knew I was forgetting something. I couldn't be done with the preflight checks already!" But that feeling soon passed, and soon we'd be jumping in, lighting the fires, pulling chocks, and rolling to the hold short (often with only one engine running, lighting the other on the go).

At the runway, lining up next to the F-14s, A-4s, F-18s, and any visiting aircraft, there was often a peculiar psychological dynamic. They all looked down on you – only natural since the F-5's stance was so low to the ground. Waving up to your buddies though, you were almost always secure in the knowledge that they would prefer to be in your seat – solo, few systems be concerned over, strictly an air combat toy. The closest one could be to a little boy 'flying' around the yard with one's arms – a pure joy.

Taking the runway for take-off gave the Tiger pilot the opportunity to exhibit one of only a couple 'gotchas' peculiar to the F-5. That low stance was pretty cool to look at, but woe to the pilot who took off in that configuration. Speeding down the runway, wondering why he felt as if he were in a dragster, and the realization would come that he had forgotten to 'extend' the nose gear strut. To increase the angle of attack for

Monty of the Saints strapping in for a 1v1 dogfight. The speed with which the F-5 could be readied for flight often left new pilots wondering if they had forgotten something. **Sean Connelley**

One of the handful of F-5Es operated by VF-126. **US Navy**



An F-5E of VFC-13 in the desert scheme on the ramp at NAS Fallon, Nevada. **Luigino Caliaro**

takeoff, and allow the aircraft to get airborne at a slower airspeed, the F-5's nose gear could be extended hydraulically. Forgetting to do so would mean one would have to attain a much higher lift-off speed, which was dangerously close to the nose wheel tyre maximum rotation speed. More than one Tiger driver has been seen extending the nose while halfway down the runway. It was a mistake most of us only made once. But once airborne, and flipping the fuel balancing switch to even up the port and starboard tanks, heaven had arrived. As strictly a simple adversary aircraft, it was a pure flying machine – not a delivery platform for weapons. The Tigers we flew in bandit land had no internal gun, which not only made them less nose heavy than 'fleet' models, it allowed for lots of room to pack a bag when we went on the road on cross countries to log that all important instrument flight time – and if there might have been a young lady at the destination airfield, so much the better.

In the 1980s, the navy's use of the A-4 and the F-5 as adversary aircraft to train the frontline fighters was both fortuitous and fortunate. They were readily available, certainly, but were also good simulators of certain Soviet model machines. In fact, they both simulated the MiG 21 well – the A-4 below 250kts, while the F-5 was very similar in performance above 250kts. We often went out together, a Tiger and Skyhawk section, to give the Tomcats the full range of threat conditions. The A-4 had a longer 'on station' time, and would often double-cycle, meaning stay for two separate individual F-14s or sections. As much fun as the A-4 was to fly, trying to remember five or six full blown engagements with two or four or more fighters was a challenge, even with our note cards and drawings we used as memory aids. The F-5 only had enough fuel for two full, or perhaps three short fights – easy to remember and debrief.

For sheer joy of the fight, nothing beat a 1v1 in-house. At every opportunity, we would try to save some fuel, or schedule in-house training, to meet up in the training areas and test our skills against each other. When pilots are flying the same model aircraft, the only difference of course is how well they can make their steed perform. A mile and half abeam each other, 300kts, fight's on – that's what most of us lived for. But a fight I found just as fun and challenging was the F-5 v the TA-4J. The two seat trainer version of the A4 had a less powerful engine than the single seat – which made it possible for the F-5 to get into a slow 'knife-fight' with it – a tactic that would have been suicide with the higher thrust A-4F. The better energy addition of the F-5 was somewhat matched by the more ➤

By 1987, aside from the F-5E and TA-4F, VF-126 had expanded its portfolio to include the A-4E, F-16N and T-2C Buckeye, all of which were used as adversary and training aircraft until the squadron disbanded in April 1994. **US Navy**

> **"OTHER THAN THE TWO 'GOTCHA' MENTIONED, THE TIGER WAS PRACTICALLY PILOT PROOF. IT WAS SO SIMPLE. NOT ONLY WAS IT SIMPLE TO OPERATE, IT WAS EASY TO MAINTAIN."**

efficient wing of the TA-4, allowing both to get into a rolling scissors, or similar fight, without the outcome being pre-ordained strictly by flight characteristics.

The slow flight in the F-5 did have one drawback – it was the flight regime where the other peculiar 'gotcha' could be found. The flaps on the F-5 were usually, and strangely, operated by a switch on the throttle (most aircraft had a lever behind the throttle quadrant that would be used to raise and lower the wing flaps). In a fight, whenever the F-5 was below about 200kts – say in a hard turn or over the top in a loop or scissors – most pilots would activate the flap switch which would extend the leading and trailing edge flaps on the wing. But, if one was on his back, inverted, and allowed the aircraft to get below about 150 knots, there was not enough stick authority to pull the nose down below the horizon and the aircraft would hang up, inverted, with the nose 10° to 20° above the horizon – and fall to the earth. The only way to get the nose down and start accelerating and flying again was to get the flaps up. Most were quick to remedy and recover after making this mistake – but more than one aircraft, and pilot, have been lost due to this particular characteristic.

Other than the two 'gotcha' mentioned, the Tiger was practically pilot proof. It was so simple. Not only was it simple to operate, it was easy to maintain. When the squadron would go on detachment to NAF El Centro in the California desert, or NAS Fallon near Reno Nevada, we would only have to take five or six F-5 mechanics to maintain the three aircraft. In comparison, to maintain three or four A-4s would entail 20 to 30 sailors. More importantly, rarely did anything 'break' on the F-5 – they were almost always in 'up' status except for scheduled routine maintenance.

The F-5F Tiger was a pure joy to fly and fight. If there is a heaven, I know what it is like; living in Southern California flying VFR in the F-5 as an air combat trainer on a daily basis. As anyone knows that has had the pleasure of comparing, being an F-5 pilot was the most fun a guy could have with his clothes on. Check Six. ■

The sleek lines of the F-5 shown to best effect as an aircraft is prepared for another adversary sortie. The simplicity of the F-5 makes it popular with air and ground crews alike. **Sean Connelley**

FLYING THE MiG-28

THE F-5 ON THE SILVER SCREEN AND AS AN ADVERSARY

By Commander Dave 'Bio' Baranek, USN (retired)

The late afternoon sun glares in my face, my dark visor barely reducing its intensity, as I speed toward destiny 20,000ft above the cold ocean. Miles ahead I see two specks, backlit against the orange sky. All I know is they are hostile. We are flying at a cautious speed of 300kts and they are about the same, and with our closing speed of 600kts I soon discern details: two tails, sharply-swept wings... these are F-14 Tomcats.

We are a flight of four, and we do not fear the American Tomcats. I focus intently as we approach our foe in a dangerous game of chicken. They quickly grow in size and slash through our formation. We narrowly avoid a collision, passing so close I can hear their engines.

I am in an aircraft few people have heard of, but many will soon recognize our sinister black shape and our aircraft will be world-famous: the MiG-28. The Tomcats curve behind us, and as we begin to show them our resolve, I hear: "Cut!"

It wasn't a dream, it was a scripted pass during a flight to film scenes for the movie Top Gun. The merge with the Tomcats gave the director the shot he wanted and he was ready to move onto the next scene. He was in a Lear 25 flying a loose formation on our black jets, and the Tomcats were real, but as a reader of this magazine you probably know that our 'MiG-28s' were really F-5s. Here's the back story on filming the movie and what it was like flying Northrop's sleek F-5F Tiger II for the camera.

THE GENESIS OF TOP GUN

Imagine a movie where jet fighters are among the stars. Most of the credit has to go to Hollywood producers Jerry Bruckheimer and Don Simpson. By the early 1980s, one or both of them could claim exciting hits such as American Gigolo, Thief, and Flashdance. In 1983 they saw an article in California magazine called 'Top Guns', which described the exploits of navy F-14 Tomcat crews going through the challenging training course at Topgun. Written by Ehud Yonay, the article was illustrated with exciting photography by one Charles J Heatley – better known in the navy fighter community as 'Heater', the callsign he used as an F-14 pilot and Topgun instructor. It was Heater's photos that lit the fuse on the film project.

These facts would be little more than curiosity were it not for the vision and passion of British director Tony Scott, leader of the team that turned Top Gun from an idea into ➤

All three of the two-seat F-5Fs operated by Topgun in the 1980s are in this photo: the photographer's mount and two wingmen. **Dave 'Bio' Baranek**

EXPLAINING MY TERMS

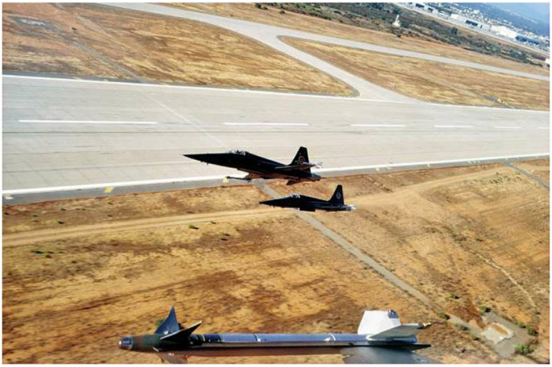
The official name of the squadron was the Navy Fighter Weapons School (NFWS), but the organization was called Topgun from the start, when it was a detachment of the F-4 training squadron at NAS Miramar. Navy personnel wrote it as one word or two words, but for this article I use it as one word to describe the squadron and two words to describe the movie.

Similarly, I use the term MiG-28 to describe flying the black F-5E and F-5F during filming of Top Gun. Several notes on the Internet claim that T-38s were used to film the movie but you can take my word for it, we flew the two-seat F-5F.

a Hollywood blockbuster. The movie was strengthened by a tried and true storyline and cast that combined exciting newcomers with seasoned actors, but we will focus on the flying scenes and the F-5's role. Scott worked closely with a handful of professionals in Hollywood and in the navy to plan and execute some of the most exciting flying ever captured on film. The flying had to support the script, look good on the screen, and be executable. Save for the use of a few models and simple special effects, the flying happened as it is seen. The Hollywood contingent included Clay Lacy, former fighter pilot and air racer. Lacy to this day is a successful Learjet dealer and leader in air-to-air cinematography. He helped plan the aerial sequences and flew the Lear camera ship that captured them on film.

Standouts among the navy personnel included Lieutenant Commander Robert 'Rat' Willard: Topgun instructor and F-14 pilot, credited as navy aerial coordinator; Lieutenant Commander Lloyd 'Bozo' Abel: F-14 pilot, credited as F-14 aerial coordinator; and Lieutenant John 'Smegs' Semcken: F-14 pilot and Topgun graduate, credited as navy cooperation and support officer. Many others contributed to making Top Gun and can rightly claim credit.

During planning for the movie, the question of enemy aircraft came up, as the hero in his F-14 would encounter the enemy several times. Using real MiGs was out of the question in 1985, and it was decided to cast one of Topgun's two types in the role. The F-5 was considered more sinister than the A-4, and chosen to portray the enemy. Realizing that the majority of the movie audience would have difficulty keeping up with who were the good guys and bad guys, it was decided to paint to F-5s black. On the other hand, to avoid comparisons with real aircraft a fake designation was used, MiG-28, and the red star and yellow circle insignia was invented to avoid comparison with real air forces.


Two MiG-28s join up seconds after lift-off. **Dave 'Bio' Baranek**

MIG-28 FLIGHT BRIEF AND MAN-UP

I had more than 1400 flight hours as a fighter radar intercept officer (RIO) when I walked into classroom number one, Topgun's main briefing room in NAS Miramar's Hangar 1. Most of my flight time was in F-14 Tomcats, but I'd been flying the F-5F Tiger II as a Topgun instructor for one year. It was 4pm on a warm Monday afternoon in August, 1985.

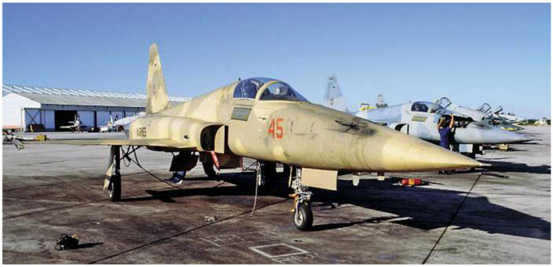
The atmosphere was more relaxed than the typical Topgun class brief: no students filled the seats, only pilot and RIO Topgun instructors and F-14 aviators from VF-51, an F-14 squadron known as the Screaming Eagles that was chosen to support the movie project. Casually-dressed civilians stood against the walls, production crew members and possibly an actor or two. We didn't crowd the actors, having already met some of them at a social hour and talked with them around the squadron. Director Scott was up front with Rat and Bozo, the pilots briefing the flight. While the formality associated with briefing a Topgun class flight was gone, the professionalism remained.

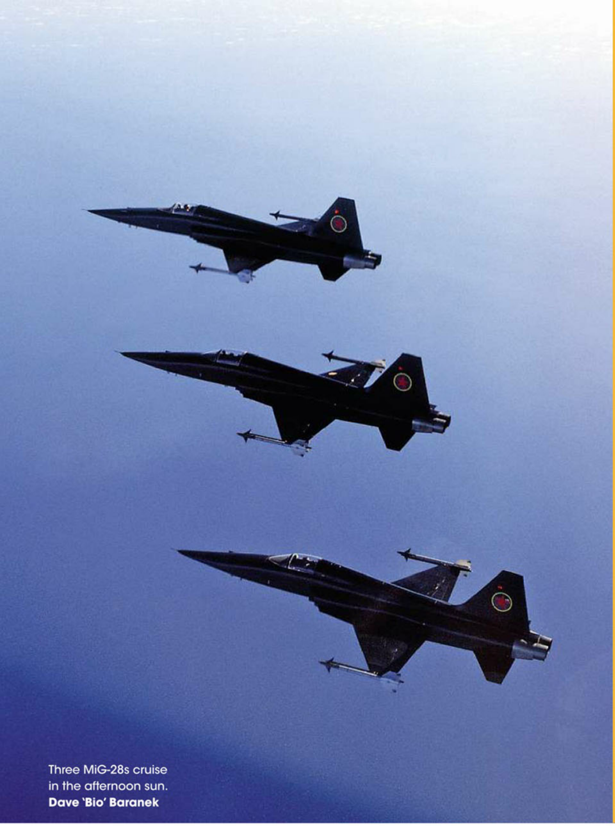
We had become comfortable with the movie project. Topgun instructors had been discussing it for months, and VF-51 crews had been flying Tomcat-only scenes for weeks, such as the Miramar tower fly-by. To help everyone get a sense of the action we were trying to capture, director Scott showed the storyboard sketches he had personally drawn, and summarized where each scene was in the script. Our main goal on this flight was to show the F-14 in a dogfight with MiG-28s, action that would be filmed from Lacy's Learjet, and we briefed several other scenes. Instead of fighter tactics, we briefed lessons from Topgun's first movie flight that morning and Lacy gave us advice about how to stay in the frame of his camera system. Borrowing a slang term for dogfighting, 'yanking and banking', he said: "Use a lot of bank and not a lot of yank."

We reviewed the mandatory safety items (emergency of the day, spin procedures) and trouped out to the wardrobe trailer. For the same reason our MiG-28s were painted black, we were to wear black flight suits and black helmets – which actually looked cool. But as I walked into the trailer, I was met by the odor of an overripe locker room. The gear had been used previously and left in the closed trailer. After a few minutes of airing out I could rush in and grab what I needed. Unfortunately I could not find a helmet that fit, but I would not let that keep me from this flight so I squeezed my head into one and figured I could tolerate the discomfort for this mission.

As I manned up I was greeted with a memorable sight. Among the dozen F-5s and A-4s on the Topgun line, camouflaged in various patterns, sat four jet black F-5s – three single-seat 'E' models and a two-seat 'F'. They had been painted over the weekend and this was my first close-up look. The paint had a slight sheen, but was not glossy. As I preflighted, I consciously reminded myself not to be distracted by the unusual paint scheme or mission.

In contrast to the lengthy preflight associated with an F-14, it only took a few minutes to walk around the F-5. Strap-in and engine start were similarly brief, and soon four black jets were waiting at the hold short. The F-14s we would be working with had already taken off, going first because of their greater fuel capacity. When Lacy's white Lear started its takeoff roll, I heard over the radio: "Topgun 47 flight, Miramar Tower. Position and hold."


On the flight line at NAS Key West, soot from the M39 cannons darkens the noses of Topgun F-5Es. The squadron occasionally deployed from its then home base of NAS Miramar to practice aerial gunnery and concentrate on training new instructors. **Dave 'Bio' Baranek**


Three MiG-28s cruise in the afternoon sun. **Dave 'Bio' Baranek**

THE TOP GUN PEOPLE

Many Navy personnel in addition to those named here made substantial contributions to the success of Top Gun. Sixteen of us were credited as Topgun Instructors and MiG Pilots. In addition, the credited technical advisor for the movie was a former Topgun instructor, Vietnam combat pilot and MiG killer, Pete 'Viper' Pettigrew. Viper was rewarded with a small on-screen role: Perry Siedenthal, the gentleman who Charlie joins in the O-club scene. Another contributor was Jim 'Flex' Destafney (also a former Topgun instructor), credited as navy dialogue consultant.

F-14 RIO Lieutenant Scot 'Kram' Krambeck appeared in the opening scene in the carrier's combat information centre, and AME1 Brian Burns provided his burgundy 1955 Chevrolet 210 Delray two-door sedan as eye candy for several scenes. Add to these flight deck personnel aboard USS Enterprise, flight line personnel at Naval Air Station (NAS) Miramar, tower controllers, and more. Some were credited, many were not, but all contributed to making the film a success.

The author briefing an actual Topgun class. The atmosphere during briefings for movie flights was more relaxed but still professional. **Dave Baranek Collection**

AIRBORNE IN A BLACK TIGER II

Four MiG-28s lined up on Miramar's parallel runways and quickly completed take off checks. A moment later we received take off clearance, and soon we were slicing through the afternoon sky, crossing the rocky coast heading out over the Pacific.

I took in the view of black fighters alongside my own black wings as I settled into the roomy cockpit. Though not as spacious as that in the F-14, it was comfortable for a small fighter. To the seat of my pants the F-5 felt smooth at low altitude. Visibility was good except for a moderate blind cone directly to the rear. As we turned south over the Pacific I took a few photos of these rare birds. They had only made one flight, but already some of the black paint was peeling. The movie crew would touch up the paint each evening and was not concerned with minor flaws.

Approaching the operating area 60 nautical miles southwest of Miramar, we joined up with the Lear and climbed to 20,000ft to set up for the first shot of the flight, the scene where Maverick and Goose fly inverted above a ➤

Topgun instructors Sunshine, Rat, and Hollywood give a mock salute after dismounting their sleek MiG-28s. **Dave 'Bio' Baranek**

An F-5F leads two E-models over Southern California, with a backdrop of dramatic clouds. **Dave 'Bio' Baranek**

MiG-28. The crew tried several times to film an actual inverted F-14 above a MiG-28, but it was proving difficult, so our shot would be part of a special effect that showed the action. Rat had our wingmen wait on the Lear's left side, while we flew to the right. Pulling alongside we saw the forward fuselage had a large glass panel which fronted a movie camera. On a radio call, Rat and I were supposed to look up quickly, as if we were startled, though there would be nothing above us.

"A little forward. That's good. When I count to three, both of you look up as quickly as you can. Remember, you're startled. One, two, three!"

I looked up. It was hard to act startled in all my flight gear and oxygen mask. We received no feedback, just a British voice that said: "Okay, let's do it again. Remember, you are startled that there is an F-14 above you. One, two, three!"

They didn't teach us this in Pensacola. We filmed the scene three times. I wasn't sure if we didn't get it right until the end or they just wanted multiple takes. Then we set up for the manoeuvring shots we had briefed.

By this time my small helmet was causing serious pain, so during a lull in the action I removed it for a few seconds and felt blessed relief. I would do this several more times during this flight.

Due to the unusual nature of this mission Rat managed the navigation and communications. He called for a left turn to stay in the area and then called one F-14 to move into position behind and below the Lear, while the other remained out of the way as we prepared to film an F-14 being menaced by multiple MiG-28s. Rat slid behind and below the F-14, posting the other black jets behind and below us. We were only flying 250 to 300kts, so the F-14 pilot manually swept his wings back to make it look like he was flying faster.

"Action!"

On the director's call, the F-14 started to bank left and right, staying within about 20° of the Lear's tail. Each of the MiG-28s had an assigned altitude band, and we banked within that band. Rat followed the F-14's motions, as if we were pursuing it, while our wingmen did the same. I was very conscious that we had to restrict ourselves to a narrow altitude band, as there were three more aircraft swinging back and forth below us.

The camera in the Lear's belly recorded everything. A real dogfight is an exceptionally dynamic contest that filled a spherical part of the sky three to five miles in diameter and would be very difficult to photograph. We were performing a piece of stagecraft, a scene that would be one of many brief sequences stitched together to convey the action.

Nice close-up of a MiG-28, as the flight proceeds to the filming area over the Pacific Ocean. You can see missing paint on two of the aircraft and the tail of the near aircraft has already been touched up. **Dave 'Bio' Baranek**

Clay Lacy's racing P-51D Mustang (N64CL). Lacy autographed the picture after the author approached the racing legend during a briefing for Top Gun and said he was thrilled to meet him. **Dave Baranek Collection**

After about a minute we heard Scott's British accent: "Cut! That's good, fellas. Let's get a little tighter on the formation so we can see who is at the end of the line down there."

Rat called for another turn to stay in the area. I took off my helmet for a few seconds. As he rolled out on the new heading, Clay Lacy called: "Steady, 210." The clipped professionalism of Lacy's radio calls revealed his extensive flying experience.

Rat said, "Okay, whenever you're ready."

"Action!"

We repeated our scene several times until reaching bingo fuel. The flight time of 1.3 hours was 0.4 hours longer than my average flight at NFWS, indicating the reduced throttle settings we were using. The real-time filming of these scenes was not as exciting as the final product, with its dramatic buildup, quick cuts, and sound effects, and certainly not as dynamic as a typical Topgun training flight.

PRESSING THE LIMITS

I flew movie flights again on Tuesday afternoon and Wednesday. On those flights I was happy to discover fresher air in the wardrobe trailer and a helmet that fit. It's amazing how important little things can be. In addition, we were able to join up with Lacy's Learjet shortly after takeoff. Though I spent much of my time airborne flying against and with the latest American fighters, it was cool to get into tight formation with an aviation icon like a Learjet, flown by a legend like Clay Lacy. I took a few photos and then we got back to business.

The Tuesday afternoon flight brought its own excitement, and it wasn't acting. At the end of each day several members of the production crew viewed the 'dailies', raw film from the day's shooting that had been processed quickly. One of the most critical shots showed two F-14s and multiple MiG-28s doing a 180-out pass. They had tried to capture this Monday morning, but the dailies revealed the pass wasn't close enough: the MiGs looked like black spots when viewed from the cameras specially mounted on an F-14. We would have to try again and the aircraft would fly closer.

January 1987: Navy Fighter Weapons School F-5E leads USAF F-15 Fighter Weapons School F-15C and F-15D out over the Pacific for a training flight. This flight pitted instructor against instructor. **Dave 'Bio' Baranek**

On Tuesday morning Rat met with the admiral responsible for Miramar's squadrons, who helped approve the movie. During the original discussions they had decided to be conservative, but now realized they would have to make some changes. Specifically, one of the safety rules for air combat training required 500ft of separation between aircraft. Rat and the admiral realized it was designed for pilots in a dynamic environment, and our movie filming flights were more controlled – so we could safely make passes closer than 500ft. But the admiral told Rat to personally lead flights with close passes, and said he would stop movie production if there were any type of mishap.

These guidelines were in our minds as we approached the operating area Tuesday afternoon. Rat reiterated the parameters for the first pass and we flew to our stations: two F-14s started on one station, and four MiG-28s 10 miles to the east. The Lear flew alongside the MiGs and offset. On Rat's call the groups turned toward each other. "Action!"

We were flying only 300kts, compared to the 400 to 600kts common for training intercepts. Wingmen used standard visual cues to help them stay in formation. Inside of a mile, both lead pilots made small adjustments to avoid collision, and wingmen adjusted slightly to hold formation. At that speed it took six seconds to close from one mile to the merge, and the Tomcats streaked past and flew out behind us.

As we set up for the next run, I know everyone was thinking: "We need to fine-tune this." Rat suggested that on the next pass the F-14s hold steady inside five miles, leaving it to the F-5s to prevent collision, as the Tomcats were easier for us to see.

The second pass was similar to the first, only tighter. The F-14s streaked past closer than the 500ft separation I was used to, but the real-time refinements to our gameplan gave me some comfort. I thought we had nailed it, and maybe even impressed the Hollywood types.

A British voice came on the radio: "That's better fellas, much better. But can we do it one more time, only a bit closer?"

A closer pass? That would be a challenge, I thought. Rat suggested a few further refinements and asked Bozo if he was comfortable. Once the F-14 lead was satisfied, Rat went over the details to satisfy everyone. We were determined to be tight enough in the camera's frame to be recognisable aircraft, grey F-14s and black MiG-28s.

On station. Ready. The Tomcats called that they were turning in and the MiGs again headed roughly west. Rat called "tally-ho," and from the back seat I could see two specks against the late afternoon sky. Then the only voice on the radio was the lead Tomcat RIO calling the distance every two miles as he tracked us on his radar. In the final few seconds the Tomcats quickly grew in size, and then suddenly blasted past us with a whoomp!

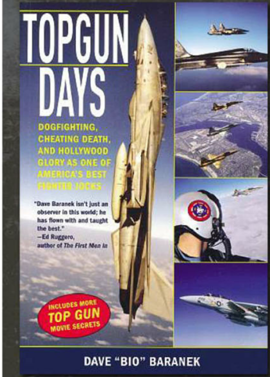
Flying in a jet, wearing a helmet, you rarely heard opponents during training events, but I heard these guys. It wasn't dangerous, but passing so close was visually more exciting than the merge in a typical training engagement. Now director Scott said: "That was good, I think we got it," and we set up to film the next scenes. But they were anti-climactic after that merge.

Filming continued for a few more days at Miramar, then the film crew, the Tomcats, and a bunch of Topgun instructors packed up and headed for NAS Fallon. Most of the filming there showed F-14s fighting Topgun's 'other jet', the A-4 Skyhawk, which represented flying in the Topgun class (I told this story in *Aviation Classics* #13, Grumman F-14 Tomcat, with the help of several pilots mentioned in this article). Several MiG-28s made the trip and did some movie flying, but filming had to avoid showing the ground as the MiG encounters in the movie took place at sea.

A few weeks after I flew the MiG-28, Smegs and I went to Paramount Studios in Hollywood to help put raw film of flying in order that made sense, and write dialogue for them. That was a fascinating glimpse 'behind the curtain' of a major motion picture. A year later, Top Gun was released to enthusiastic audiences, went on to become the highest-grossing picture of 1986, and still has many fans worldwide. For me, the movie still brings back vivid memories of a MiG encounter that I can tell you about – and I won't have to kill you. ■

TOPGUN DAYS

To read more about the MiG-28 and the making of Top Gun, check out Dave 'Bio' Baranek's book TOPGUN DAYS: Dogfighting, Cheating Death, and Hollywood Glory As One of America's Best Fighter Jocks. Bio takes readers along on exciting flights when he was a nugget in his first Tomcat squadron, including his split-second ejection during a carrier landing mishap. He then tells what it took to become a Topgun instructor, and gives a fuller account of the filming of Top Gun. The recently released softcover includes new material on filming the movie. See more at www.TopgunBio.com


TOPGUN DAYS
DOGFIGHTING, CHEATING DEATH, AND HOLLYWOOD GLORY AS ONE OF AMERICA'S BEST FIGHTER JOCKS
"Dave Baranek isn't just an observer in this world; he has flown with and taught the best." —Ed Ruggero, author of The First Men In
INCLUDES MORE TOP GUN MOVIE SECRETS
DAVE "BIO" BARANEK

The author's memoir TOPGUN DAYS describes the reality of flying the F-14 Tomcat, becoming a Topgun instructor, and filming the movie Top Gun. The new softcover version has more than 50 colour photos and includes a new chapter that goes into detail on the F-14 Tomcat scenes in the movie. **Dave 'Bio' Baranek**

On display!

F-5 and T-38 aerobatic teams of the world

The Northrop F-5 fighter and T-38 trainer have been the mounts of nine aerobatic display teams, some short-lived, some from surprising countries and two still flying and thrilling crowds today. The aircraft in either single or two seat form is ideally suited to display flying; its sleek lines making for an impressive visual display, its high performance demonstrating the truth of that appearance. Unashamedly, this part of the magazine is a celebration of the art of these teams. Enjoy!

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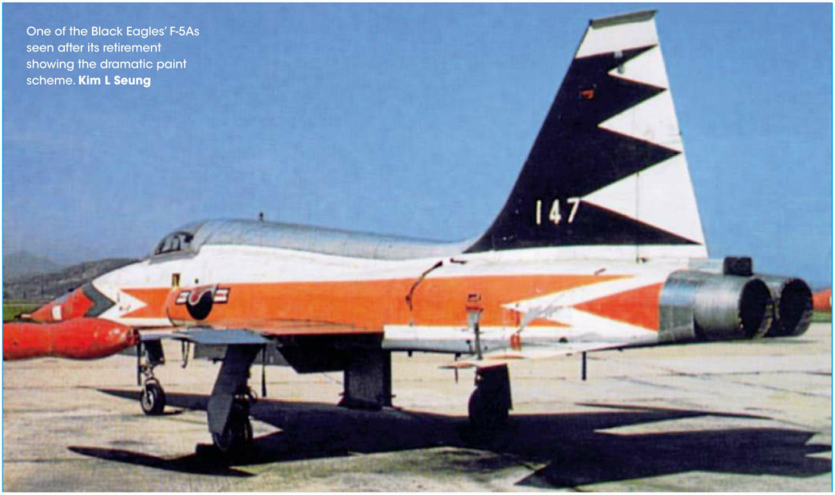


One of the Black Eagles' F-5As seen after its retirement showing the dramatic paint scheme. **Kim L Seung**

The pilots of the Black Eagles with their F-5As. **Kim L Seung**

THE BLACK EAGLES

The first display team of the Republic of Korea Air Force flew four North American F-51 Mustangs and was formed on October 1, 1953. This was followed by the T-33 Show Flight Team of 1956 and the Blue Sabre team of 1959. The latter flew four North American F-86 Sabres and was to delight crowds and fly ceremonial duties until 1966. In October 1967, the first team with the name the Black Eagles was formed with six specially painted Northrop F-5A Freedom Fighters all of which had white smoke generators. Between 1970 and 1972, the team was temporarily suspended, re-forming on RF-5As which were flown until 1978 when it was disbanded due to defence requirements. After the F-5, the Black Eagles team rose again in 1994 using six Cessna T-37B Dragonfly trainers until its disbandment in 2007 to work up on its brand new aircraft, the Kai T-50 Golden Eagle. From 2009, the Black Eagles team has thrilled crowds with its dynamic and close formation display, winning awards at air shows around the world.

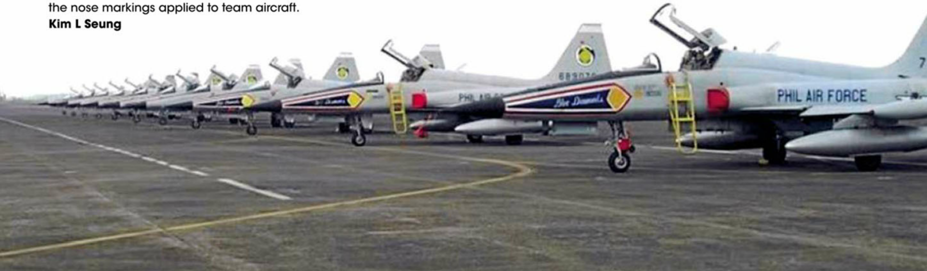
THE BLUE DIAMONDS

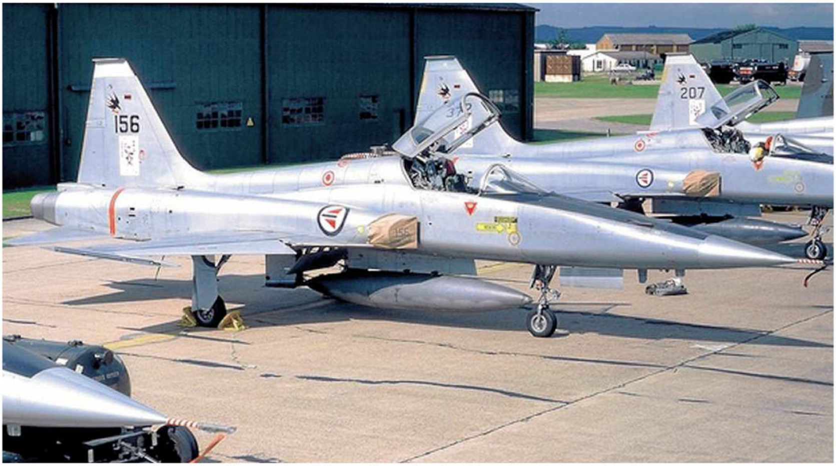
Like the Korean Black Eagles, the Blue Diamonds team of the Philippine Air Force was formed in 1953 using North American P-51D Mustangs under First Lieutenant Jose Gonzalez. These aircraft were followed by North American F-86D Sabres in 1959 and Northrop F-5A Freedom Fighters in 1968. The team was disbanded and re-formed several times until September 2005, when the F-5 was finally withdrawn from service, having been the subject of a number of upgrades in the intervening years. The planned modernisation of the Philippine Air Force may yet see the re-formation of the team.

THE FLYING JOKERS

Based at Rygge Air Base, 332 Squadron of the Royal Norwegian Air Force was the unit behind the formation of the Flying Jokers military display team in 1959, flying four North American F-86F Sabres. The team was disbanded in 1963 but re-formed with three Northrop F-5A(G)s in 1966, displaying throughout Europe until 1973. Throughout its existence, the team display consisted of a three ship formation and a solo aircraft, with an additional spare aircraft attending shows in case of unserviceability. The team re-formed in 1976 as part of 336 Squadron, taking part in the Royal International Air Tattoo at Fairford in the United Kingdom in 1977, after which it was disbanded for the last time.

The three single seat F-5As of the Blue Diamonds of the Philippine Air Force showing the nose markings applied to team aircraft. **Kim L Seung**





The Northrop F-5As of the Flying Jokers, the team from 332 Squadron of the Royal Norwegian Air Force. **F-5 Archive**

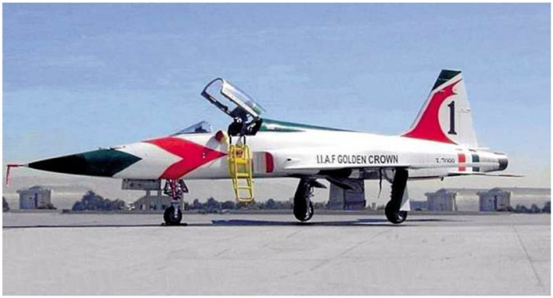
THE GOLDEN CROWN

One man could be said to be responsible for the formation of the Imperial Iranian Air Force (IIAF) military display team, Captain, later Major, Nader Jahanbani. During the early 1950s, 15 IIAF pilots attended a training course at Fürstenfeldbruck Air base in Bavaria, aimed at introducing the pilots to the new jet aircraft about to be delivered to Iran. Also based at Fürstenfeldbruck were the Skyblazers, the US Air Forces in Europe display team flying Republic F-84E Thunderjets. Captain Jahanbani was most impressed and returned to Iran, promoted to major at the completion of his training and now a qualified jet instructor, to press for the formation of a national aerobatic team. This was granted in 1958 with the formation of a four-ship aerobatic team on the Republic F-84G Thunderjet. In June, the team was officially recognised as a unit and named the Imperial Iranian Air Force Golden Crown AcroJet Team. The aircraft were painted in a red, white and green scheme that was to change little throughout the team's long career. The team increased in size to a nine aircraft formation in 1959, returning to a six ship in 1960. The following year saw an equipment change when the North American F-86F Sabre was introduced, initially six aircraft, reducing to four in 1963, then establishing as a five aircraft team until 1967.

In 1968, the Golden Crown team was equipped with five Northrop F-5A Freedom Fighters, but only for that year, reverting to the F-86F for 1969 and 1970. It returned to the F-5A in 1971 and was to fly the type as a five and six ship team until 1976, when it re-equipped with the Northrop F-5E Tiger II. Initially a seven ship team, for the last two years of their existence, 1977 and 1978, the Golden Crown was an eight aircraft formation team. The Islamic revolution of 1979 brought the team to an end.

NEW HELLENIC FLAME

The Hellenic Air Force had established an aerobatic team known as the Hellenic Flame between 1958 and 1964. Initially this team flew five, then seven Canadair Sabre Mk.IIs and established an international reputation with displays all over Europe. Three years after this was disbanded, a new team called the New Hellenic Flame began training in July 1967. Equipped with five Northrop F-5A Freedom Fighters, the team was part of 337 Squadron. It flew just two displays before it was disbanded. ➤



The Imperial Iranian Air Force Golden Crown team flew both the Northrop F-5A and F-5E in this striking red, white and green scheme. **Reza Heshemi**

Nader Jahanbani, the man responsible for the formation of the Golden Crown team, pictured later in his career as a general. **Reza Heshemi**

PATROUILLE SUISSE

Based at Emmen Air Base in Switzerland, the Patrouille Suisse flies six immaculate Northrop F-5E Tiger IIs. The Patrouille Suisse was formed on August 8, 1964, with four Hawker Hunter Mk.58s, increasing to five aircraft in 1970. In 1978, the team made its first international appearance at the Salon de Provence in France, this time with six aircraft. From 1991 onwards, the team began applying the red and white colours of the Swiss flag to its aircraft as part of the commemoration of the 700th anniversary of the Swiss Confederation. In 1994 the last displays on the Hawker Hunter were flown, the Northrop F-5E Tiger II replacing these, fully resplendent in an all red and white colour scheme. A white smoke system was added to the team's aircraft in 1996, and since then the six Swiss fighters in their extremely close formations have established a reputation for excellence throughout Europe. The team consists of seven pilots and two commentators along with a support groundcrew of engineers. The display itself is made up of both formation and solo elements, including some incredibly close crosses and tight formations. As the images on these pages more than testify, a chance to witness the team in action is one of the highlights of any air show. This fact is made all the more remarkable by the fact that the aircrew are all full time fighter pilots in the Swiss Air Force. They only fly with the team during the season.

THE SIX SWISS FIGHTERS IN THEIR EXTREMELY CLOSE FORMATIONS HAVE ESTABLISHED A REPUTATION FOR EXCELLENCE THROUGHOUT EUROPE

The Northrop F-5E Tiger IIs of the Patrouille Suisse during a practice sortie from their base at Emmen, over the stunning scenery of their homeland. The Swiss flag flies high. **Luigino Caliaro**

THE THUNDERBIRDS

The United States Air Force official air demonstration team, the Thunderbirds, was formed on May 25, 1953, at Luke Air Force Base in Arizona under the designation of the 3600th Air Demonstration Unit. Flying the Republic F-84G Thunderjet, the team initially comprised of four aircraft carrying out formation aerobatics. The Republic F-84F Thunderstreak swept wing fighter replaced the earlier straight winged type in 1955 for just one season, before the Thunderbirds became the first supersonic aerobatic team in 1956 with the adoption of the North American F-100C Super Sabre. The same year also saw the team move to its current home of Nellis Air Force Base on the outskirts of Las Vegas, Nevada. If the air display director requested it, the solo aircraft would make a supersonic run as part of the show. In 1964, the massively powerful Republic F-105B Thunderchief replaced the F-100Cs for just six performances by the team, but a structural failure with the type caused the team to return to the F-100C and later F-100D, in fact the Super Sabre was to equip the team for over 12 years. In 1969, the Thunderbirds re-equipped with the McDonnell Douglas F-4E Phantom II, which it was to fly until 1974. The incredible power of this aircraft gave the team's name new meaning as the sound of six F-4s is not so much heard as felt. The fuel crisis of the early 1970s drove the decision to replace the F-4s with the Northrop T-38A Talon two seat trainer, the high performance of which was to delight the crowds until 1981. No shows were flown in 1982, as the team was busy re-equipping with the General Dynamics F-16A Fighting Falcon, an aircraft it has used to this day. The 2013 season sees the team celebrating its members' 60th anniversary as 'America's ambassadors in blue'.

The team leader's Northrop T-38A Talon of the USAF Thunderbirds. **USAF**

THE THUNDER TIGERS

Originally known as the Thunder Tigers Technical Flying Corps, the aerobatic display team of the Republic of China Air Force was formed at Tainan Air Base in Taiwan. It flew its first display on August 14, 1954, using four Republic F-84G Thunderjets, a type known as the Thunderbird in Taiwan. In 1956, the team became officially designated as Flight Technical Corps of China Air Force Thunder Tigers, increasing in size to a nine aircraft display team the following year. The F-84s were replaced by the North American F-86A and F Sabre in 1959, 11 of them no less, making the Thunder Tigers one of the largest teams in the world. The Northrop F-5A Freedom Fighter replaced the F-86s in 1967, which were upgraded in 1975 with the introduction of the F-5E Tiger II, known as the Chung Chen in Taiwan. The team was to fly five F-5Es until November 1988, when they were replaced with the AIDC AT-3 two seat trainer, the aircraft the team's pilots still fly today. The seven AT-3 aircraft are flown by instructors from the Air Force Academy in Tainan.

Later, the Thunder Tigers upgraded their F-5As to the F-5E. **Kim L Seung**

THE TURKISH STARS

The first jet aerobatic team of the Turkish Air Force had been formed in 1952, known by the callsign Milli, which meant National. It flew four Republic F-84G Thunderjets in displays up to 1962 and was part of the 9th Air Base Command at Balikesir. In 1955, another team, the Flying Swans, was formed as part of 4th Air Base Command at Eskisehir. It flew nine, then later 12, North American F-86E Sabres for 10 years before being disbanded. Alongside these, the 8th Air Base Command at Diyarbakır established the Scorpions aerobatic team, also flying the F-84G, which flew displays in 1958 and 1959, including a number in Pakistan. A second F-86 team, the Bats, was founded in 1964 at the 5th Main Jet Base Command at Merzifon. For two years, the Bats flew displays with five, nine and 12 aircraft until it was disbanded in 1966. It was followed by the first team to be equipped with the Northrop F-5A Freedom Fighter, callsign Eagle, which formed in 1966 as part of the 6th Main Jet Base Command at Bandırma and flew displays until 1971.

The Türk Yildizlari, or Turkish Stars, was founded on November 7, 1992, as the national aerobatic team of Turkey, flying the Canadair NF-5A and B single and two seat versions of the Freedom Fighter. These aircraft were purchased from the Royal Netherlands Air Force and were completely refurbished and upgraded then painted in the team's striking red, white and silver colour scheme. Ten single seat and six two-seat aircraft are used by the team today, based at the 3rd Main Jet Base Command at Konya. Initially, the team's display consisted of seven aircraft, but in 2004 one more aircraft was added to the formation expanding its display repertoire. In recent years, this impressive team's pilots have flown at venues all over Europe, their ebullient, exciting and highly professional display making them a firm favourite among air show crowds. The images here show just how close the Turkish Stars formations are.

■ *Words: Tim Callaway*

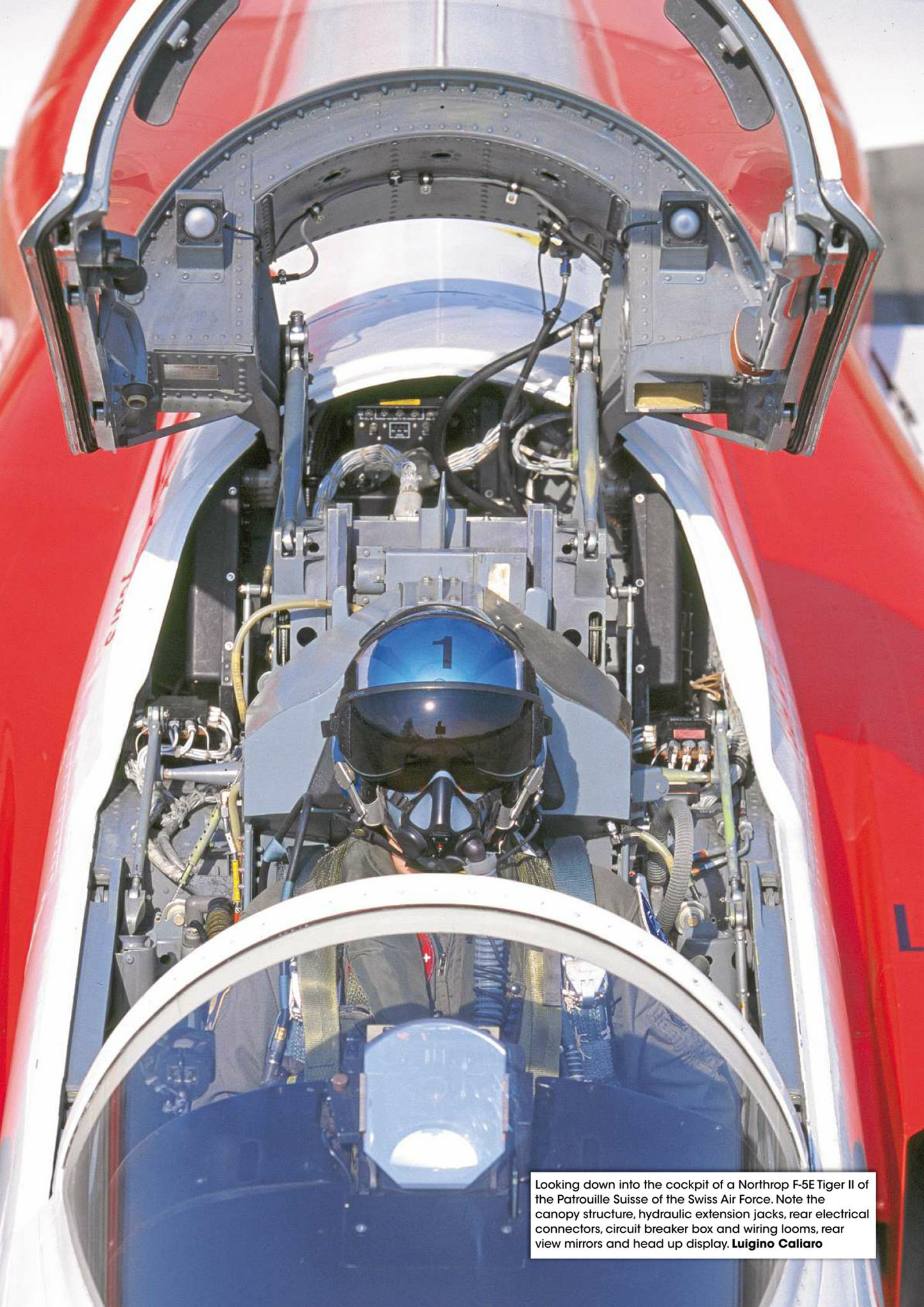
The Northrop NF-5As and Bs of the Turkish Stars during a practice sortie from their base at Konya. The close formations and precision flying have become a trade mark of this excellent team. **Luigino Caliaro**

The Turkish Stars display includes a series of close formation manoeuvres by a pair of their NF-5As. **Constance Redgrave**

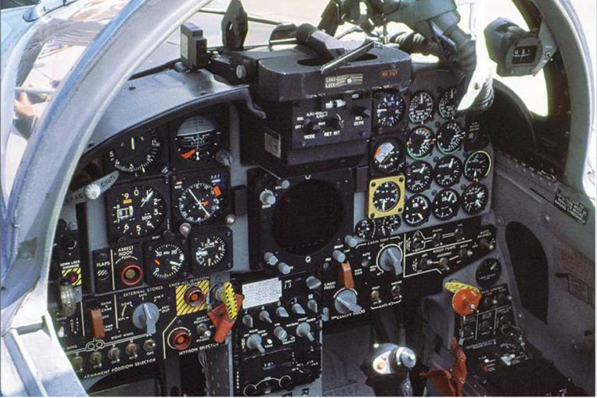
The success of any display team is dependent on its hard working groundcrew. Here, the Turkish Stars engineers prepare the aircraft for a display at the ILA, the Berlin Air Show in 2012. **Constance Redgrave**

PATROUILLE SUISSE

Four of the six Northrop F-5E Tiger IIs of the Swiss national aerobatic team, the Patrouille Suisse, perform a Diamond Break during the Swiss Air Force's Axalp Live Fire Event in Switzerland in 2012. The team was formed in 1964 and has established a reputation for excellence throughout Europe.



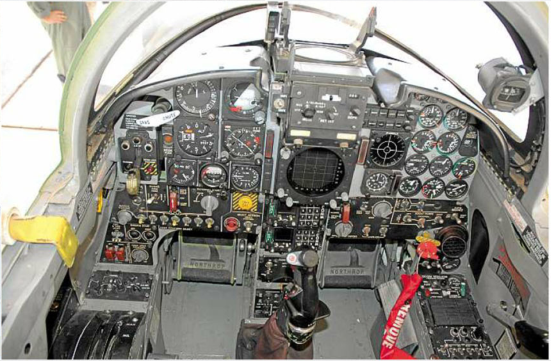
Looking down into the cockpit of a Northrop F-5E Tiger II of the Patrouille Suisse of the Swiss Air Force. Note the canopy structure, hydraulic extension jacks, rear electrical connectors, circuit breaker box and wiring looms, rear view mirrors and head up display. **Luigino Caliaro**



Left: An early USAF F-5E cockpit from the 1970s with the original radar screen mounted in the centre under the head up display. **USAF**

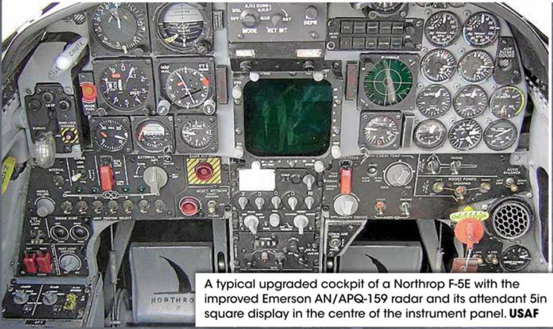
Below left: The rear cockpit of a Northrop T-38 Talon of the Portuguese Air Force. Note the view afforded the instructor over the student's head in this superb training aircraft. **Luis Rosa**

Below: The cockpit of a former USAF F-5E now in service with the US Marine Corps as an aggressor aircraft with VMFT-401 at MCAS Yuma. Note the addition of a threat warning receiver display to the right of the radar in place of the standby artificial horizon which has been moved to the left panel. **Luigino Caliaro**



Inside the F–5

A closer look at Northrop's elegant design



A typical upgraded cockpit of a Northrop F-5E with the improved Emerson AN/APQ-159 radar and its attendant 5in square display in the centre of the instrument panel. **USAF**

The F-5 and its derivatives were designed from the outset to be lightweight, simple aircraft with very low operating and maintenance costs. This was achieved through designing a strong but simplified structure throughout the airframe, using the tried and tested General Electric J-85 turbojet, itself simple and lightweight, and minimising the avionics suite. Here we take a photographic tour of this thoroughbred aircraft and its systems.

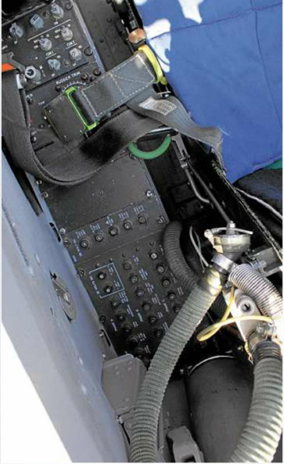
Right: Looking down at the port side cockpit panel of an NF-5A of the Turkish Stars, showing the circuit breaker panel, rudder trim and radio panel. This group of photographs were all taken in this aircraft. **Constance Redgrave**

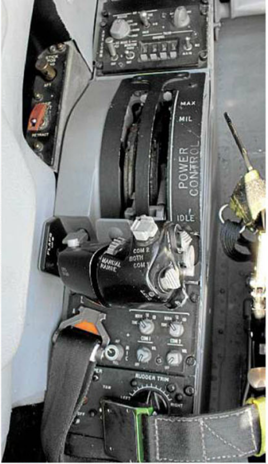
Far right: The forward port side panel of an NF-5A of the Turkish Stars, showing the throttles and the auxiliary communications and TACAN panel. The red gated switch inset into the side of the fuselage is the nosewheel strut retraction or extension control. **Constance Redgrave**

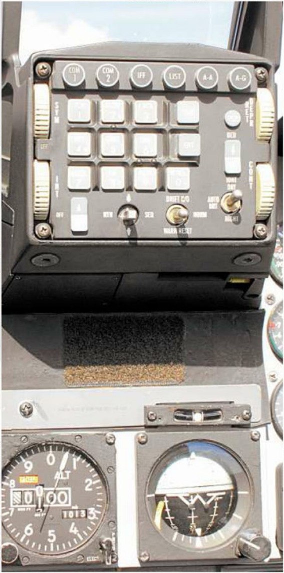
Below right: The upper centre panel with the head up display control, slip indicator ball, altimeter and artificial horizon. **Constance Redgrave**

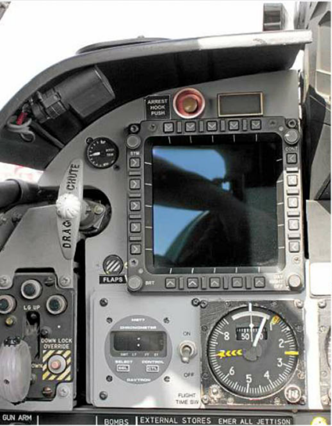
Below: The upper port panel with the arrester hook deployment button, elevator trim indicator, drag chute handle, multi-function display, flight time clock and combined airspeed and Mach meter. **Constance Redgrave**

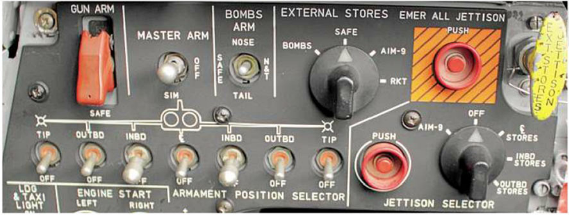
Bottom: The armament control panel on the lower port side of the main panel, showing the arming and selections switches and yellow emergency external stores jettison handle. **Constance Redgrave**

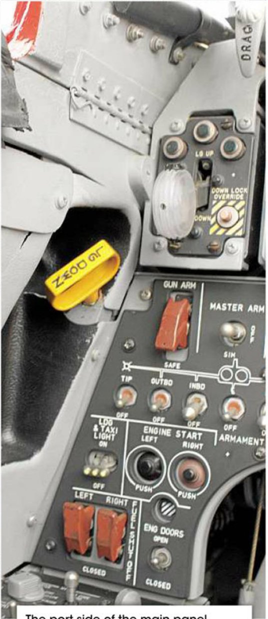




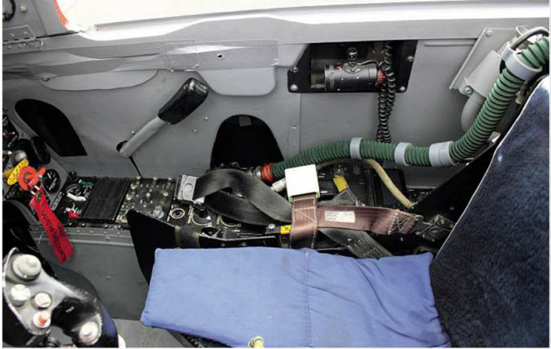


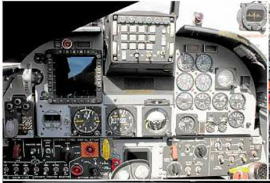


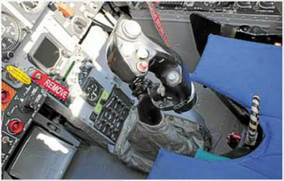


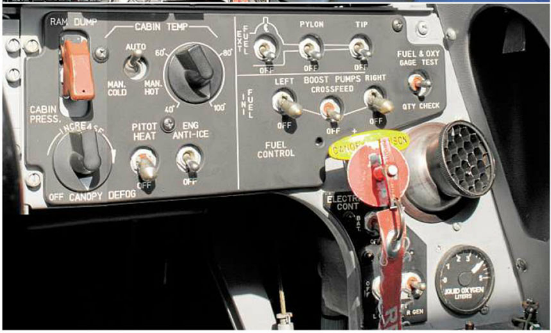


The port side of the main panel showing, from the top, the drag chute handle, the undercarriage extension lever and warning lights, yellow emergency gear extension handle, the weapons station and master arming switches, landing light switch, engine start buttons, fuel shut off switches and engine auxiliary doors switch. **Constance Redgrave**









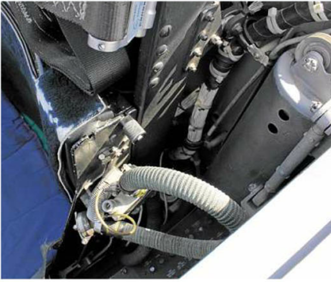
Left: The starboard side panel of the cockpit showing, from the front, the oxygen regulation panel, avionics control switches, canopy locking level, alarm test buttons lighting control panel, oxygen connector hose, cockpit recorder panel, map light and circuit breaker panel. **Constance Redgrave**

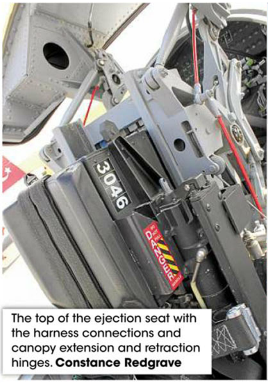
Far left: The entire main panel showing how all the pieces fit together. **Constance Redgrave**

Left: The head of the control column and lower centre panel showing the navigation panel, cabin pressure gauge, rudder pedal adjustment handle and circuit breaker panel. **Constance Redgrave**

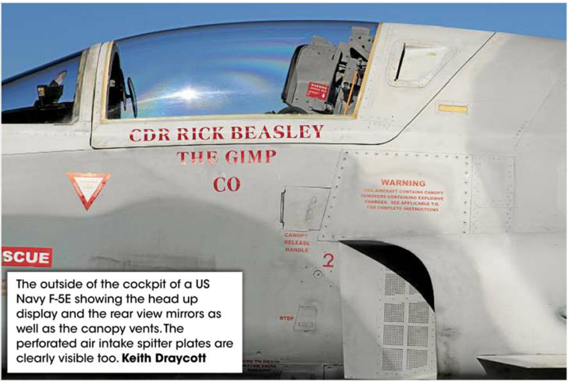
Below left: The lower starboard panel with the cabin pressure and temperature controls, internal and external fuel tanks and fuel pump controls, main battery and electrical generator switches, oxygen quantity gauge and emergency canopy jettison handle. **Constance Redgrave**

Below: Looking down the port side of the seat with the G-suit connector. Also visible is part of the wiring loom and the canopy actuation cable system. **Constance Redgrave**

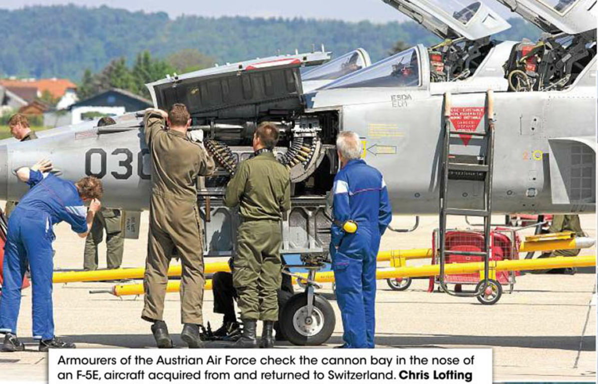




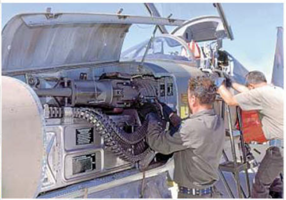
The top of the ejection seat with the harness connections and canopy extension and retraction hinges. **Constance Redgrave**

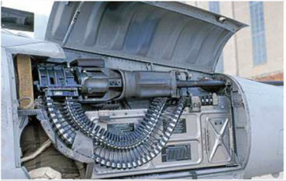

CDR RICK BEASLEY
THE GIMP
CO
WARNING
THIS AIRCRAFT CONTAINS CANOPY REMOVERS CONTAINING EXPLOSIVE CHARGES. SEE APPLICABLE T.O. FOR COMPLETE INSTRUCTIONS
CANOPY RELEASE HANDLE
2
STEP
SCUE

The outside of the cockpit of a US Navy F-5E showing the head up display and the rear view mirrors as well as the canopy vents. The perforated air intake spitter plates are clearly visible too. **Keith Draycott**



Armourers of the Austrian Air Force check the cannon bay in the nose of an F-5E, aircraft acquired from and returned to Switzerland. **Chris Lofting**





Top: An armourer of the Turkish Air Force checks the ammunition feed to the port M39A2 20mm cannon of an NF-5A. **Luigino Caliaro**

Above: The starboard M39A2 cannon of an F-5E of the Brazilian Air Force. **Luigino Caliaro**

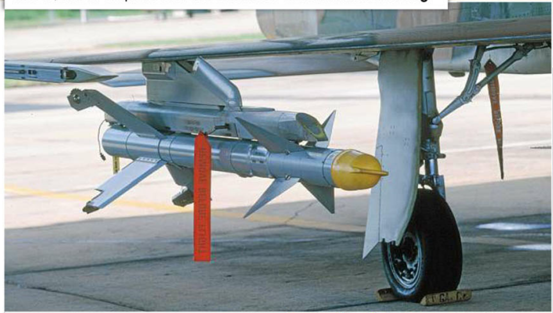
Left: Forward view of the Rafael Python 3 air-to-air missile under the wing of an F-5EM of the Brazilian Air Force. **Luigino Caliaro**

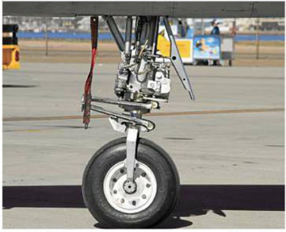
Far left: The nosewheel leg of a US Navy F-5E. The leg can be extended by thirteen inches to increase the wing angle of attack for short take offs. **Keith Draycott**

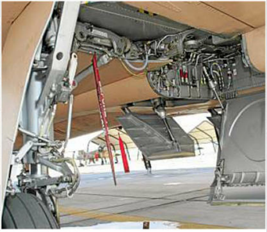
Left: Looking up into the port main wheel bay of an F-5E of VMFT-401 of the US Marine Corps. **Luigino Caliaro**

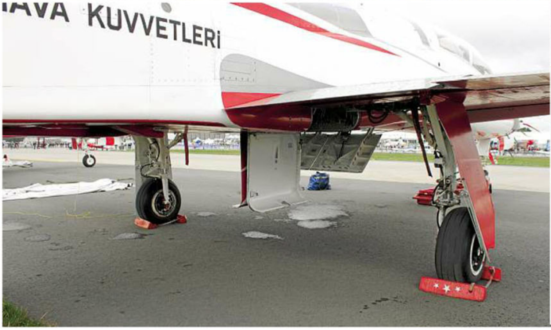
Below right: The main undercarriage legs of an NF-5B of the Turkish Stars, showing the almost one piece airbrake positioned just ahead of them on the two seat version of the aircraft. **Constance Redgrave**

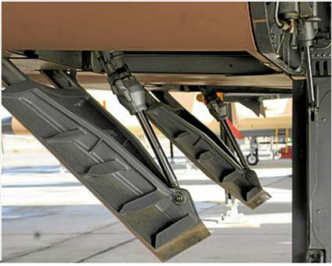
Below: A close up of the twin airbrakes of an F-5E of VMFT-401 of the US Marine Corps. **Luigino Caliaro**

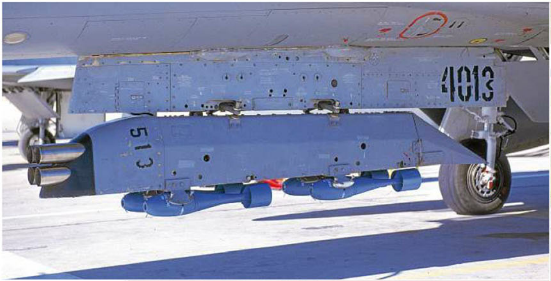


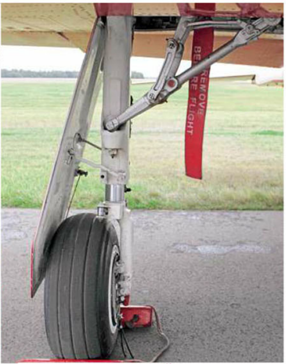


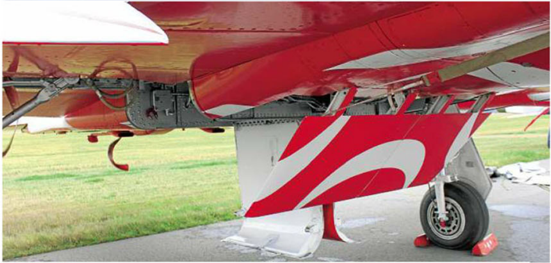


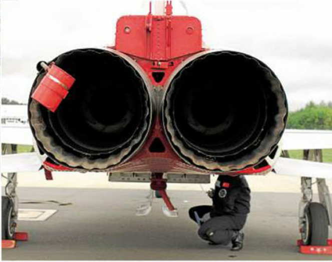


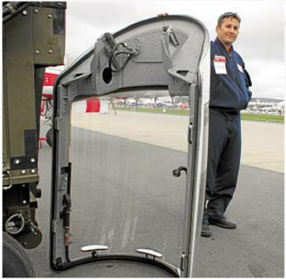




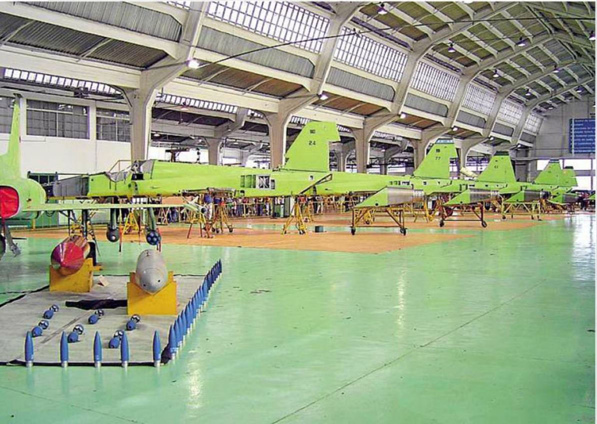








A view down the tailpipe to the back of the starboard General Electric J-85 turbojet of a Turkish Stars NF-5B. **Constance Redgrave**



Top left: A combined 25lb practice bomb rack and air to ground rocket pod mounted on the centreline pylon of a Turkish Air Force NF-5B trainer. **Luigino Caliaro**

Top right: A front view of the starboard main undercarriage leg and bay of a Turkish Stars NF-5B. **Constance Redgrave**

Above left: The nearly single piece airbrakes and leading edge slats of the Turkish Stars NF-5B are clearly visible. Constance Redgrave

Above: The twin tailpipes of a Turkish Stars NF-5B showing the drag chute housing and actuators and the smoke oil injector can that produces the characteristic white smoke trail. **Constance Redgrave**

Far left: Tamer Eski of the Turkish Stars with the canopy from one of the NF-5As. This was removed with no ground support equipment, showing how easy the F-5 is to maintain in the field, even major tasks are straightforward for a good ground crew. Note the connectors for the pressure seal and the rear view mirrors. **Constance Redgrave**

Left: The entire rear fuselage comes away in one piece for ease of access to the engines and systems. These are F-5Es being refurbished in Brazil for the Brazilian Air Force. **Renato Viani**

Ultimate and unusual F-5s

The F-20, X-29, SSBD, Taiwanese and Iranian developments

The simple and lightweight F-5 airframe also proved to be extremely adaptable to a variety of uses, some of which required extensive modifications to the airframe. The success of the fighter with international air forces also led to the development of an advanced version intended as a replacement. As well as the developments by Northrop, two additional unlicensed life-extension and redesign programmes have been carried out by HESA in Iran to produce a viable fighter bomber for the Islamic Republic of Iran Air Force (IRIAF).

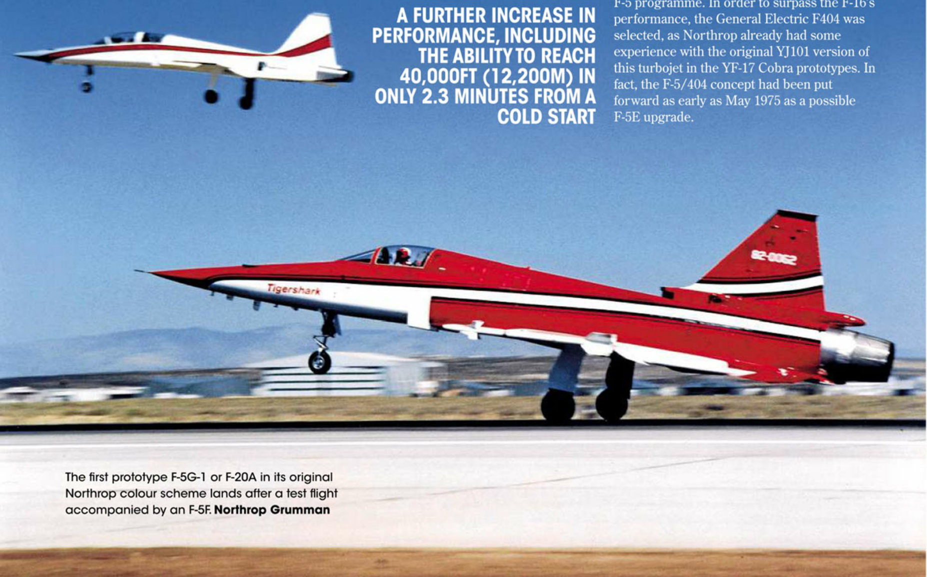
THE NORTHROP F-20 TIGERSHARK

The increasing capabilities of Soviet Bloc aircraft throughout the 1970s meant that several F-5E customers, especially Taiwan, pressed the US to provide greater capabilities for the fighter, such as an improved radar and the carriage of the semi-active radar guided AIM-7 Sparrow missile. The US Department of Defence requested that Northrop study the feasibility with which a suitable radar could be fitted to the F-5E, resulting in a design known as the F-5G. Changes in the US Government's weapons export policy in 1977 meant that this study was never taken any further, but by the end of the decade, this policy had caused a number of US Allies to seek advanced fighter aircraft elsewhere, such as the aerospace industries of France and Britain.

On January 4 1980, a new competition for an export fighter, known as the Intermediate Export Fighter or FX, was begun by the State Department in order to recapture this market and appease America's allies. Northrop reissued the F-5G proposal, General Dynamics responded with a lower powered, simpler version of the F-16, known as the F-16/79. With the inauguration of Ronald Reagan as US President in 1981, politics were again to interfere in the development of the F-5. Initially, the FX project was approved, then shelved, as the export of front line equipment was now allowed, then resurrected in 1982 as a fully-fledged programme. However, by 1980 Northrop realised that the new F-5 model would have to at least be on a par with the F-16 in terms of performance and capability, as the little fighter was now in direct competition with it.

To meet these performance requirements the F-5G proposal was much modified, resulting in the new designation of F-20 and the name Tigershark being applied to the project in 1983. The redesign began with basing the aircraft on a single and much more powerful engine, a concept that had been under design study since the beginning of the F-5 programme. In order to surpass the F-16's performance, the General Electric F404 was selected, as Northrop already had some experience with the original YJ101 version of this turbojet in the YF-17 Cobra prototypes. In fact, the F-5/404 concept had been put forward as early as May 1975 as a possible F-5E upgrade.

A FURTHER INCREASE IN PERFORMANCE, INCLUDING THE ABILITY TO REACH 40,000FT (12,200M) IN ONLY 2.3 MINUTES FROM A COLD START



The first prototype F-5G-1 or F-20A in its original Northrop colour scheme lands after a test flight accompanied by an F-5F. **Northrop Grumman**

The first X-29A in flight. **Northrop Grumman**

This choice alone called for wide ranging changes to the fuselage design, which had to be 5in longer with bigger inlet ducts and redesigned ramp doors to accommodate the greater amount of air the engine required at the greater than Mach 2 projected maximum speed. The wing did not change much, except for modifications to the leading edge extensions, which improved the lift performance for a minimum of increase in wing area, and internal strengthening to take the stress of 9G loading. A 30% larger tailplane was added to improve the pitch rates the aircraft could achieve and reduce its turning radius, an improvement assisted by the addition of a new fly-by-wire control system. Improved avionics and radar would allow the carriage and delivery of a greater range of weapons than previously.

The first aircraft, initially known as the F-5G-1, was essentially a re-engined F-5E with a modified rear fuselage to accommodate the General Electric F404 of 16,000lb (7257kg) thrust. Little else was changed. It was given the serial 82-0062 and the civil registration N4416T and test pilot Russ Scott made the first flight for 40 minutes on August 30, 1982, from Edwards Air Force base in California's Mojave desert. The performance that the 60% increase in thrust gave the fighter was astounding, enabling it to fly in excess of Mach 2 and reach an altitude of 55,000ft (16,800m). The lower fuel consumption of the F404 also gave an increase in range of 10% over the J85 engined version. The sustained turn rate was also improved to 11.5° per second at Mach 0.8, the supersonic turn rates were also improved by 47%.

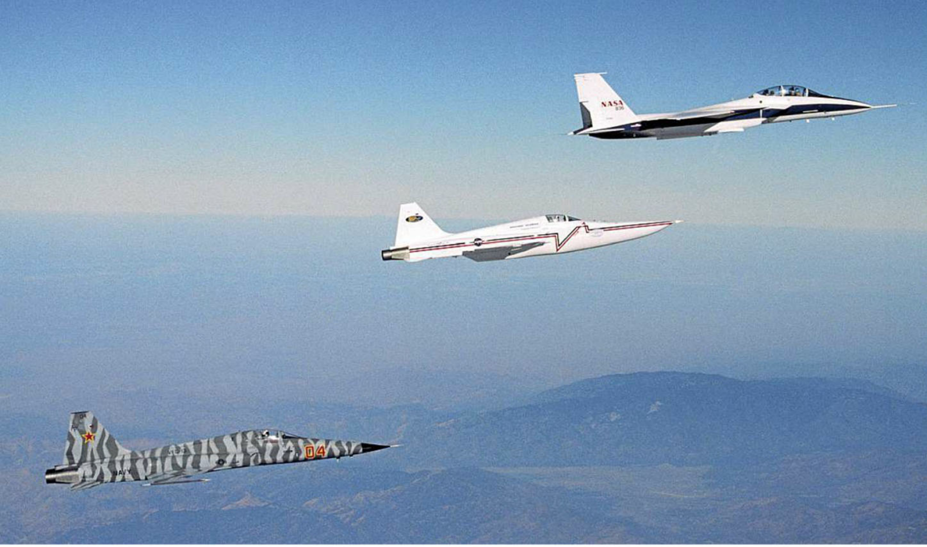
The test flying proved so successful that an initial order had been placed by Bahrain in November 1982 and evaluation by 10 overseas customers had been completed by April the following year. In June 1983, the original F404 engine was replaced by an F404-100 with an additional 1000lb (454kg) of thrust which offered a further increase in performance, including the ability to reach 40,000ft (12,200m) in only 2.3 minutes from a cold start. On August 26, 1983, the second prototype, 82-0063 (N3986B) made its first flight, featuring a completely redesigned nose to accommodate the full advanced avionics suite and the General Electric G-200 radar.

The canopy was also redesigned, featuring a bulged hood to give the pilot greater visibility. Known initially as the F-5G-1, this aircraft was followed by 82-0064 (N44671) with a similar full avionics suite and modified nose which first flew on May 12, 1984. A fourth prototype was built using the intended production tooling, incorporating larger fuel tanks, improved flap and slat actuators, General Electric AN/APG-67 multi mode air-to-air and air-to-ground radar and yet another 1000lb (454kg) of thrust from an upgraded engine. The airframe was redesigned to incorporate composite panels and structure, improving still further the power to weight ratio. The F-20A had arrived, as all the aircraft were redesignated as such in the light of the extensive modifications to the original design.

Northrop was in discussion with a number of potential customers when tragedy struck. Test pilot Darrell Cornell was killed on October 10, 1984, when demonstrating the first prototype, 82-0062, in South Korea. Less than five months later in May 1985, Northrop test pilot David Barnes was killed at Goose Bay in Labrador while en route to the Paris Air Show. He was practicing his display as part of a company demonstration and crashed under similar circumstances to Darrell Cornell. In both cases, no failure was found in the aircraft or its systems, but the crashes had an effect on the programme and delays were inevitable.

Despite its high performance, the USAF and the overseas customers increasingly favoured the F-16, so interest in the F-20 dwindled. Bahrain replaced its F-20A order with one for 10 F-5Es and two F-5Fs, and in 1986 the USAF announced it would be purchasing the F-16 for both the Air National Guard and the Aggressor squadrons, both roles envisaged for the F-20. Later that year, Northrop realised the hoped-for overseas market had been won over by the widely supported F-16 and the $1.2 billion F-20 was finally cancelled. The F-20 was a jewel of a high performance aircraft, completely privately funded by Northrop. Without doubt, its cancellation was a blow to the company, but it was already busy with the development of the B-2 Spirit stealth bomber. ➤

The cockpit of the first X-29A. **Northrop Grumman**



The F-5 SSBD with the NASA F-15B and VFC-13 F-5E with which it conducted the SSBD and SSBE flights. **NASA**

THE X-29

Two F-5A airframes, 63-8372 and 65-10573 were converted by Grumman to become the only X-29As, 82-0003 and 82-0049 respectively. These aircraft were extensively modified with canard foreplanes and 33º forward swept main wings and were intended to act as flying testbeds to investigate the aerodynamics of such a configuration. Since forward swept wings suffer from aerodynamic twisting forces which can be sufficiently strong to destroy them, only the extensive use of modern composite materials allowed the construction of a sufficiently strong wing to fully explore the performance.

The wing made the aircraft extremely unstable, and was only flyable by way of a triple redundant computerised flight control system. On December 14, 1984, Grumman's chief test pilot, Chuck Sewell, took the first X-29A into the air at Edwards Air Force Base, four months after which NASA began an extensive test flying programme using both aircraft. The X-29s proved extremely reliable for such an advanced concept, reaching an unheard of angle of attack of 67º and becoming the first forward swept wing aircraft to fly supersonically, the latter achievement occurring on December 13, 1985.

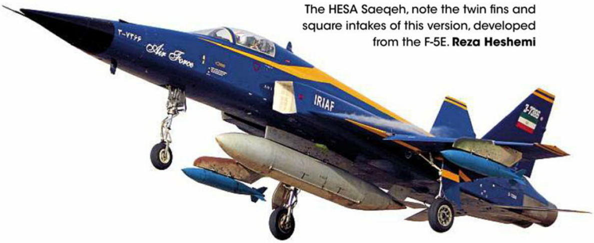
The first aircraft was retired in 1986 after 242 successful flights, the second aircraft continuing to fly until 1991. They are both on display today, the first at the National Museum of the USAF at Wright Patterson Air Force Base in Ohio, the second at the Dryden Flight Research Centre at Edwards Air Force Base in California.

THE SSBD

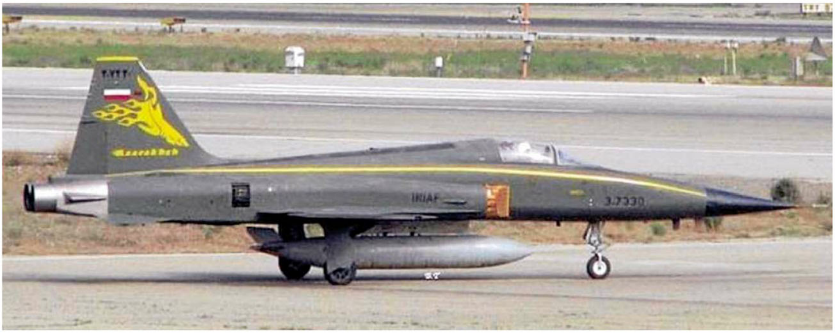
Without doubt the strangest looking of the F-5 developments, the Shaped Sonic Boom Demonstrator, or SSBD, was a modified F-5E with a bulged forward fuselage. The aircraft was to demonstrate that sonic booms created by aircraft could be substantially reduced by special shaping techniques and allow unrestricted supersonic flight over land. Northrop Grumman as the firm now was, Northrop having purchased Grumman in 1994, won the Defence Advanced Research Projects Agency (DARPA) competition to produce the test aircraft in July 2001 as part of the Quiet Supersonic Platform programme.

Northrop's F-5 was considered ideal to modify to the required smoother equivalent area distribution as it was known, as it was a simple and reliable platform. A US Navy F-5E was restructured at Northrop Grumman's St Augustine facility in Florida, using modified components constructed at the company's El Segundo plant in California. The first part of the flight testing was aimed at establishing the flight envelope of the modified aircraft before the SSBD flights could begin. Making its first flight on July 24, 2003, from St Augustine and Cecil Field in Florida, the envelope was expanded with a T-38 in support to include supersonic flight at Mach 1.1, before the aircraft was flown to Palmdale in California.

With the support of a NASA F-18 from the Dryden Flight Research Centre, the flight envelope tests were completed and the SSBD flights began at Edwards Air Force Base throughout August 2003, several occurring on August 27. These were conducted over an area strewn with ground sensors under the aircraft's flight path and to either side to record sonic boom and pressure wave generated by the aircraft. On three flights a standard F-5E from VFC-13 at NAS Fallon in Nevada flew 45 seconds apart from the SSBD to provide a comparison shock wave. Both aircraft were flying at 32,000ft and Mach 1.4 in the USAF High Altitude Supersonic Corridor. Two more flights were conducted with a NASA F-15B fitted with a pressure measurement probe to assess the shockwave near the SSBD.



The HESA Saeqeh, note the twin fins and square intakes of this version, developed from the F-5E. **Reza Heshemi**



One of the early HESA Azarakhsh developments of the F-5E in IRIAF service. **Reza Heshemi**

These flights showed the SSBD did indeed have a reduced sonic boom, and a second series, known as the Shaped Sonic Boom Experiment or SSBE, was then conducted in January 2004, again over Edwards, by NASA. Altogether 21 flights recording the sonic boom pressures in varying flight conditions and turbulence were conducted, eight with the standard F-5E and four with the F-15B. In addition, a Blanik L-23 glider from the USAF Test Pilots School was fitted with several sensors and was flown 10,000ft below the SSBD on 13 of the flights. More than 1300 sensor recordings were made and 45 probe data sets were compiled, the aim being to allow future aircraft designers to control the sonic boom produced by their aircraft. The F-5 SSBD is now on display at the Valiant Air Command Warbird Museum at Titusville in Florida, and will eventually be placed in the National Museum of Naval Aviation at Pensacola.

TIGER 2000/2001

The Republic of China Air Force (ROCAF) had purchased the F-5A and B as early as 1964 and by 1975 the Aerospace Industrial Development Corporation of Taiwan was producing the F-5E and F locally in their hundreds. The aircraft were replaced by the Mirage 2000, F-16 and the AIDC F-CK-1 Ching-kuo, also known as the Indigenous Defence Fighter (IDF) during the 1990s, but at least 40 were still in service in training roles into the 2000s, with between 90 and 100 maintained in reserve. AIDC began the Tiger 2000/2001 programme with a view to upgrading these second line aircraft, using the GD-53 radar from the F-CK-1 fighter. The GD-53 was a development of the General Electric AN/APG-67 multi mode radar intended for the F-20, which was itself originally a development to meet Taiwanese defence needs. A single prototype flew for the first time on July 24, 2002, but official disinterest ended the programme. The prototype remains on display at AIDC in Taiwan.

AZARAKHSH, SAEQEH AND SIMORGH

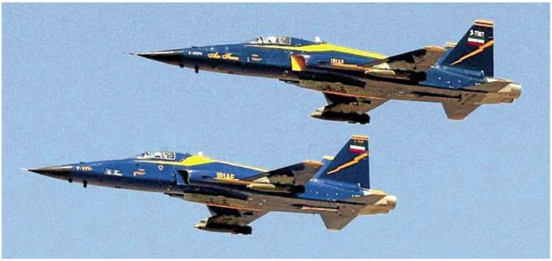
With the Iranian Islamic Revolution of 1979, support for the many US aircraft purchased by the deposed Shah was no longer available. Since then, the Iranian Ministry of Defence, the Islamic Republic of Iran Air Force (IRIAF), its Owj Industrial Complex (OIC) and the Iran Aircraft Manufacturing Industrial Complex (HESA) have undertaken modification and upgrades using existing equipment as a basis. These programmes have been the subject of much speculation so here is what little information I have been able to confirm.

The first of these, the Azarakhsh (Thunder) was first announced in April 1997 and is believed to be a Northrop F-5E Tiger II with a Russian developed radar which extended the nose by some 6.6in (17cm). This entered series production in June 1999, with between six and nine being built by 2001 against an order for 30. A second prototype flew in February 2001 with strengthened wings, wide use of composites throughout the airframe, uprated J85 engines and the ability to carry locally manufactured weapons. Little is known about the use of these aircraft, but two single seat and a two seat aircraft based on an F-5F took part in the National Army Day flypast at Tehran on April 17, 2008. An enlarged version of the F-5E, also known as the Azarakhsh, was planned, using Russian engines and radar, but was not built as far as can be ascertained. The next version was revealed in 2008, and was a major redesign having its wing mounted in the centre of the fuselage, above the air intakes, to increase its ability to carry underwing loads. The wing was also fitted with a leading edge extension to improve manoeuvrability.

The Saeqeh (Lightning or Thunderbolt) first flew on May 30, 2004, having begun development in 1998. Confusion over the prototypes of this aircraft comes from the use of the name Azarakhsh-2 in relation to the first prototype. The Saeqeh has fins, canted outboard, similar to the F-18, and two different versions are known to exist, one with similar intakes to the F-5, others with enlarged square intakes, possibly representing a second version of the type, first seen in August 2006. The intended production version of the aircraft is believed to feature an advanced radar and a full glass cockpit. Three of the fighter bombers took part in the National Army Day flypast at Tehran in both 2007 and 2008, but it is unknown how many have been built.

The Simorgh is the last Iranian F-5 development, driven by the lack of two seat training aircraft. HESA is undertaking the conversion of the remaining Northrop F-5A Freedom Fighters in storage into two seat versions, similar to the F-5B. ■

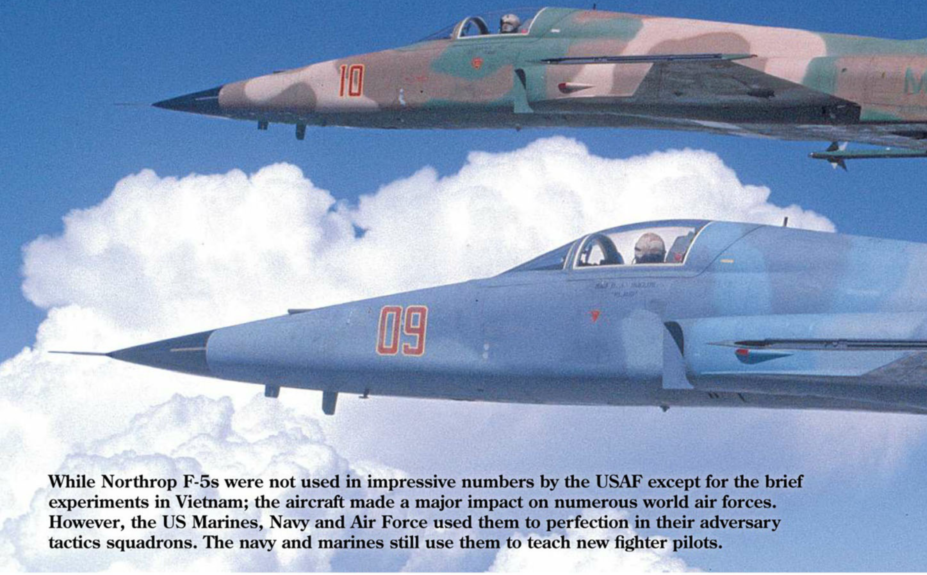
Words: Tim Callaway



The second version of the HESA Saeqeh with the F-5 type engine air intakes. It is unclear which version was built first. **Reza Heshemi**

Adversary tactics

US Marine F-5 Tiger IIs



While Northrop F-5s were not used in impressive numbers by the USAF except for the brief experiments in Vietnam; the aircraft made a major impact on numerous world air forces. However, the US Marines, Navy and Air Force used them to perfection in their adversary tactics squadrons. The navy and marines still use them to teach new fighter pilots.

The USAF had four aggressor squadrons at one point during the Cold War years with the Soviet Union. The latter stages of this era saw these units beginning to convert to the newer F-16s. From 1973 until 1990, the 527th AS served at RAF Alconbury which covered USAF squadrons serving in Europe; the 26th AS covered dissimilar training out of Clark AFB in the Philippines while the 64th and 65th Squadrons covered CONUS out of Nellis AFB Nevada. The navy has upgraded its F-5s numerous times and purchased three dozen low time F-5E/Fs from Switzerland in 2006. The primary aggressor squadrons for the navy are VFC-111 based out of NAS Key West and VFC-13 based in Nevada. However, the lone marine aggressor squadron remains intact at MCAS Yuma Arizona (VMFT-401).

The marine squadron was activated in mid-March 1986 and in June 1987 it received its first fighter which was the Israeli F-21A (aka: Kifir). This addition totalled 13 aircraft. Squadron records state that on September 22, 1989, it transferred all 13 F-21As back into Israeli inventory. At that time, it received 11 USAF F-5E Tiger IIs. During the remainder of that first year of operation with the F-21A's, the marine aggressor pilots logged more than 4000 hours of flight time while participating in 16 important exercises.

The official mission of VMFT-401 is: "To provide instruction to active and reserve Fleet Marine Force and Fleet Squadrons through the simulation of adversary aerial combat tactics; to be prepared to execute adversary aerial combat tactics against both fixed and rotary wing aircraft; and to be capable of deployment to conduct training to include exercise training." The author visited the pilots of VMFT-401 back in the early 1990s during the period when the Cold War had wound down but the emphasis remained on teaching the latest Russian combat tactics used by the MiG-21 and MiG-23 units.

Major D J Miner was one of the more experienced marine pilots in the squadron with 1400 hours in the F-5 and 700 hours in the F/A-18 Hornet. He gives some insight into the heavy regimen that the aggressor pilots are involved in: "As a squadron, we fly about 4500 sorties per year. As of this date, we have 13 F-5s and one of them is a two seat model. The 4500 sorties equate to 3900 hours per year. Our average sortie runs about 45 minutes which means we fly clean with no external fuel tanks because the range is very close to us here in Yuma. Our F-5Es were all built around 1973 and each airframe has about 8000 hours of flight time. As of this time, we have about 20 pilots on our roster with most of them being in the Marine Reserves and seven are on active duty. Most of our 'part-timers' fly with the airlines.

"All of us are marine combat tactics instructors who have numerous hours flying in the F/A-18 Hornets or the Harriers. We also have a couple of pilots who have time in

A superb high altitude view of two F-5Es from VMFT-401, The Snipers. **Luigino Caliaro**

the F-16. A lot of our guys are weapons tactics instructor types. Most of us have gone to Topgun and all have been instructors prior to this assignment. The minimum to be considered for the programme at this time is 1000 hours." At the time of the author's visit, the average age of the marine aggressor pilots was 32-35 and the average rank was major.

The day-to-day missions flown by the squadron break down into the following: one third support the fleet replacement squadron that is based at Miramar; one third of the sorties go to the fighter weapons programme for their students and the remaining third go to support the Marine Aviation Weapons Tactics School at MCAS Yuma. The latter has two main courses every year which occur in the spring and autumn. This involves six weeks of flying where the marines bring in everything to the party: Harriers, Hornets, Cobras, Helos, Frogs etc. At first the aggressors work with each individual squadron (one aircraft type). Gradually, this ➤

The sleek lines of the Northrop F-5E are shown in this picture taken at VMFT-401's home base at MCAS Yuma, Arizona. Note the numerous shelters in the background that kept the aircraft out of the hot Arizona sun. **Warren Thompson**

All of the marine F-5s were kept in top shape year-round due to the heavy work schedule they had. There were very few bad weather days over the desert near Yuma. **George Sares via Warren Thompson**

The USAF aggressor squadron that handled adversary tactics in Europe was the 527th. This was taken at RAF Alconbury in 1987. **Al Kamerer via Warren Thompson**

Climbing for altitude, Lt Col Lauritzen manoeuvres to gain the advantage for a fight against navy Hornets from VMFAT-101. **Mark Lauritzen via Warren Thompson**

evolves into an exercise that has the F-5s going up against an entire marine air group with ground troops also involved.

"Most of our time is spent fighting MAG-13, here at Yuma, and MAG-11 out of Miramar. The guys from Miramar fly directly to the range that we use and most times they return to their base after the fight without having to land at Yuma. The enemy aircraft that we replicate the most are the MiG-21 and MiG-23. At this time we have pulse-only radar and it cannot replicate the pulse-Doppler radar like the MiG-29 and Su-27 has. We do the tactics right out of the book with no surprises. The new pilots coming into '401 not only have to learn to fly the F-5E, they also have to learn all the tactics cold. We are very hard on each other and we have to make sure none of us are deviating from the tactics that we have to teach."

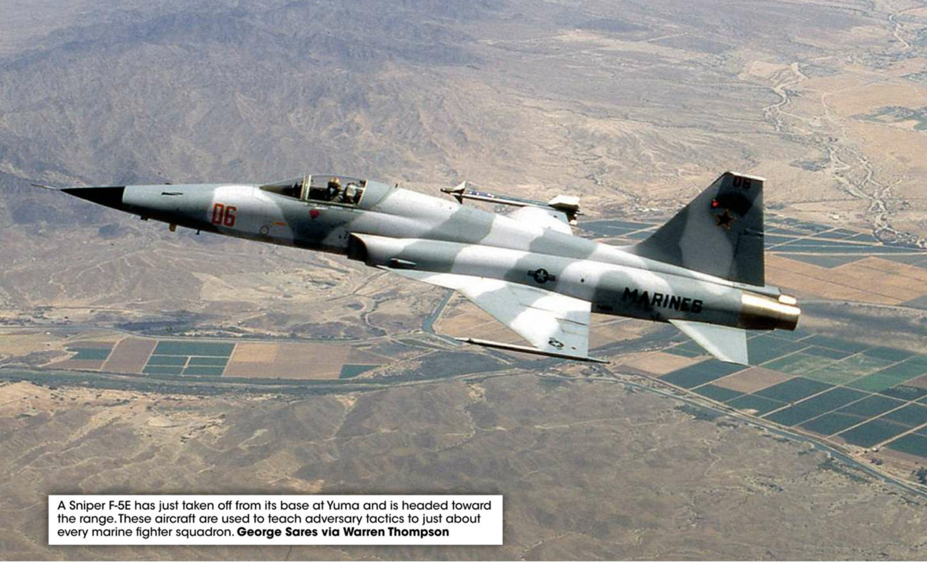
Most of the squadron's action is carried out in the Yuma area. VMFT-101 usually runs the new fighter weapons classes through every four to six weeks. So for two weeks at a time, '401 has its hands full with them. Two to three times a year, the squadron ranges out to the East Coast to MCAS Beaufort, MCAS in South Carolina and MCAS Cherry Point in North Carolina etc., usually in the spring and autumn. On some occasions they support some USAF F-16 types that are usually out of Luke AFB, Arizona, when they are not busy teaching tactics to the marine units.

One of the leaders assigned to VMFT-401 was Lieutenant Colonel Mark Lauritzen. He adds some interesting details of how the squadron operates: "The navy's adversary tactics programme and our programme run in parallel. We come under the navy's Omnibus of the Adversary Squadron concept and contract maintenance etc. Our aircraft are owned by the navy. Topgun is the mainstay of the tactics and standardisations and we follow all the tactics laid down by that organisation which is all inclusive of what the real world threat may be at the time according to what hostile country we are replicating in the scenario out on the range. We will send our pilots to the Topgun adversary training course to teach them what we consider to be the common threat tactics. There is not a lot of difference, philosophically or conceptionally, between how we see things and how Topgun sees them. There is a lot of rivalry, but this is because we are different squadrons."

In the years before the marines had their own aggressor squadron, they had a definite need for these services and they got it from other navy fighter units on both the east and west coasts. The problem that soon developed was that as the tactics became more complex and the corps was getting into state-of-the-art aircraft such as the F/A-18, the navy could not provide what was needed either through the Topgun training classes or trying to support big joint exercises where all the latest tactics came to light. So VMFT-401 was commissioned in March 1986 and became

At least twice a year the Sniper force from '401 flies from MCAS Yuma, Arizona, to take on the marine Harriers and Hornets from MCAS Cherry Point, North Carolina. This was taken as they made a fuel stop at NAS Memphis, Tennessee, in the spring of 1992. **Warren Thompson**

This Aggressor F-5E is inverted, at altitude, over the badlands of Arizona right after an exercise against Navy F/A-18s. The pilot is Lt Col Mark Lauritzen. **Mark Lauritzen via Warren Thompson**



A Sniper F-5E has just taken off from its base at Yuma and is headed toward the range. These aircraft are used to teach adversary tactics to just about every marine fighter squadron. **George Sares via Warren Thompson**

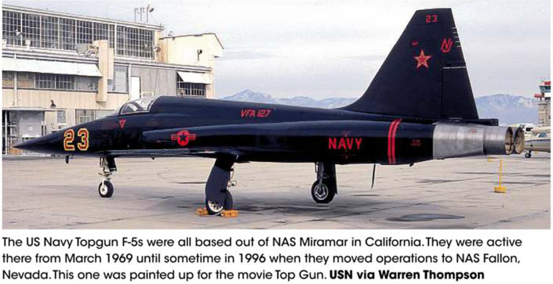
Major 'Waco' Dennis over the desert in his Sniper F-5E. **Luigino Caliaro**

operational in September 1987 with the Israeli F-21 KFIR. Two years later they would transition into the Northrop F-5.

Lt Col Lauritzen continues: "Not only do we support the F/A-18 squadrons but we also do work with the Harrier units. We fly a lot of missions over Twenty Nine Palms in California where we will simulate an airborne threat that flies over ground troops in a mock strafing attack, or we will run surface attack profiles on the Hawk missile batteries that are operated by the marines. Or we'll fly strike intercept scenarios with C-130s, AV8 Harriers, OV-10s, and many times there are helicopters involved in the exercises. So we have many unique missions that the navy squadrons do not have and realistically they could not support these if we requested it from them. They just do not have the assets or resources available."

At the time of these interviews with '401, most flying time supports the Marine F/A-18 Replacement Squadron training of young pilots in dissimilar air combat manoeuvring (ACM) while another segment goes into the weapons and tactics instructor course (WTI) exercises that last about six weeks and after that, support goes over to the marine ➤

The maintenance personnel who worked on the marine F-5s had an outstanding record. They were civilian contract specialists who were paid by General Dynamics. This was taken at MCAS Yuma during the hottest months of summer. Note the protective shelter that kept the sun off the aircraft. **Warren Thompson**



The US Navy Topgun F-5s were all based out of NAS Miramar in California. They were active there from March 1969 until sometime in 1996 when they moved operations to NAS Fallon, Nevada. This one was painted up for the movie Top Gun. **USN via Warren Thompson**

This was taken over Eastern North Carolina during combat exercises that pitted VMFT-401 against MCAS Cherry Point Hornets. **Mark Lauritzen via Warren Thompson**

A Sniper F-5E in the blue scheme approaching MCAS Yuma. **Luigino Caliaro**

A Sniper F-5E in the desert scheme taxis on the ramp at MCAS Yuma. **Luigino Caliaro**

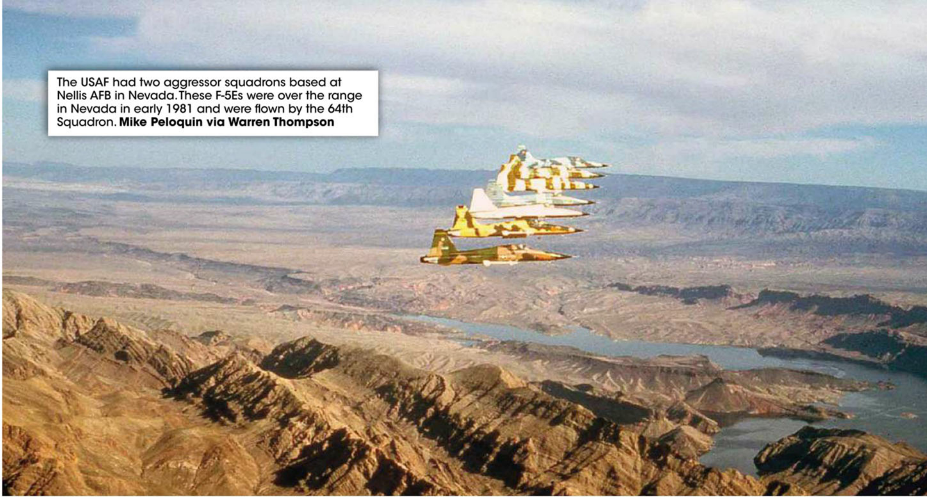
fleet squadrons. Becoming an aggressor pilot in the marines has certain requirements as mentioned earlier. After they are selected for this role, they will go through a very stringent academic course as well as flight build-up, and finally the certification part of that is through the Marine Aviation Weapons and Tactics Squadron (MAWTS-1) team at Yuma.

They go out and administer a test to each of the pilots. If they pass the exam, there will be a series of three flights that they will fly on with the primary focus on: the pilot's ability to brief, to instruct, to create a game plan and to execute that plan in the air according to what the threat is; the missiles they have on board and how they employ their radar; reconstructing or debriefing that particular flight in a way that the learning points are brought out in a very low-key manner. Once the new pilots have passed everything, they are capable of flying lead as a mission commander for any dissimilar ACM events including a 1v1 scenario all the way up to multi v multi packages.

Lt Col Lauritzen said he enjoyed flying the F-5E: "My experience with the F-5E prior to coming into '401 involved several things. I used to work with the guys from Topgun when they had the F-5 and I was fortunate to fly against the USAF aggressors out of Nellis AFB (64th and 65th Squadrons). Incidentally, we are flying many of the air force's F-5s today as they all converted over to the new F-16s. It is a great little fighter to fly with overall good performance. Against the F-4 Phantoms, it had a slight advantage in turning performance and it is much more difficult to see because of its small size. When you get engaged with the F-5, it can intimidate you very much with its tight turns, but if you know that aircraft's performance stats and fly smart, you can do quite well against it even in the F-4 and especially in the F/A-18 Hornet.

"In my early days of flying against the pilots in Topgun, I got beat up pretty bad a few times, but it was mainly because I tried to work the vertical with them at the higher altitudes in my Phantom and it would not turn as well as the smaller F-5s. I learned quickly to fight them down low and to stay in a two-

The terrain in the area around Yuma is every bit as magnificent as the F-5E. **Luigino Caliaro**



The USAF had two aggressor squadrons based at Nellis AFB in Nevada. These F-5Es were over the range in Nevada in early 1981 and were flown by the 64th Squadron. **Mike Peloquin via Warren Thompson**

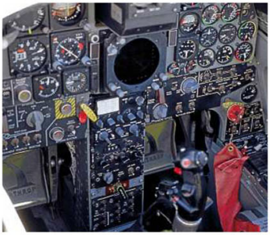
circle type of sustained energy fight against them. If I were still in the F-4 and fighting the adversary tactic F-5s, I would meet them head on, turn across their tail and try to drag him down low so I could energize my aircraft's performance. Fighting against an F-5 with an experienced pilot is extremely tough."

The fact that this outstanding Northrop fighter is small, fast and deadly has a lot to do with its international sales success, but those are not the only reasons. Maintenance requirements are also a reason for so many of the world's air forces buying the fighter. In the early 1990s, General Dynamics was the primary contractor for maintenance on the Marine F-5Es based at MCAS Yuma. Former Gunnery Sergeant Fred King was one of the crew chiefs at the base. He explains how easy it was to keep all of the squadron's fighters in service: "A majority of my experiences while active was with marine Phantoms (B, J, N and J models). The F-5E Tiger II is a tremendous tactical fighter based on what I have heard from the pilots who fly it. Maintenance-wise, to a certain degree, it requires very little down time to get it ready for the next flight. It was designed to work in a very simple manner, especially compared to the larger, heavier fighters. The F-5 dates back to the mid-1960s and is currently being flown by numerous air forces. All three branches of the US military have flown it and it is still considered a front line fighter by many of the countries that bought it (early 1990s).

"When a problem crops up with it, we can usually solve it quickly with very little down time. The same goes for engine changes. It can also be noted that these aircraft do not leak very much compared to the F-4 and a few others. My assigned aircraft carries the number 12 and has the name Excalibur. It has a unique paint scheme that makes it next to impossible to spot when it is hugging the deck in desert terrain. All of the crew chiefs here at MCAS Yuma have their own assigned aircraft and we all take great pride in making sure they are in top notch condition when the pilots climb in the cockpit for a training mission. In my opinion the most formidable trait that the Tiger II has is its turnaround time. In a critical situation, these aircraft could be in the enemy's face several times a day!"

As of 2013, VMFT-401 was still using the F-5 at MCAS Yuma to prepare the new pilots for combat. ■ *Words :Warren E Thompson*

The sleek head-on image emphasizes the low visual profile of an aggressor F-5 coming straight on. This was taken at MCAS Yuma. **Warren Thompson**



The instrument panel in the cockpit of one of the F-5Es of VMFT-401. **Warren Thompson**

The 26th Aggressor Squadron was a USAF unit that taught adversary tactics to squadrons in the Far East. This was taken at Clark Airbase in 1984. **Chris Shaw via Warren Thompson**

The T-X programme
Replacing the irreplaceable

The success story of the Northrop T-38 Talon two seat trainer in service with the USAF, NASA and the air forces of five other nations has been an enduring one. For 52 years the sleek supersonic jet has been the stepping stone to the cockpit of modern fast jets for innumerable trainee pilots. Now, those aircraft in service are undergoing a life extension programme of upgrades and refurbishment that will keep them in service until at least 2020, but a replacement is being sought for the period after that date.

A pair of upgraded Northrop T-38C Talons of the 90th Flying Training Squadron, 80th Flying Training Wing at Sheppard Air Force Base, Texas. **USAF**

The draft proposal to replace the T-38, the T-X programme as it is known, was released in October 2012 and is actually a complete training package rather than just the aircraft. Networked flight simulators and weapons system trainers with simulated motion systems to provide a realistic flight experience, as well as computer based training software for the aircraft's systems, are included in the requirement, along with the need for between 350 and possibly as many as 1000 aircraft.

These new aircraft will not only have to fulfil the fast jet pilot training role, but the fighter fundamentals training course as well. The proposals include the need for the aircraft to be able to reach a loading of 7.5G and an initial turn rate of 12º per second, as well as the ability to conduct high angle of attack (AoA) manoeuvring at 20º degrees AoA or greater. The internal fuel capacity must be sufficient for repeated visual range engagements to be carried out in a single sortie and the aircraft must be fitted with a refuelling probe to allow 'dry' contacts with a tanker aircraft for training purposes.

The full glass cockpit is to be fitted with simulated radar, threat warning receiver, situational awareness and data links, all capable of operation with night vision goggles, which is intended to introduce the trainee to the data management tasks required of the modern fighter pilot of such aircraft as the F-22 Raptor and F-35 Lightning II.

Lastly, the aircraft must be able to simulate the delivery of a wide range of air to air and air to ground weapons. The entire training system must also be modular in design and upgradeable over time to maintain parity with front line equipment. The full requirement is expected to be released in late 2013.

The T-X proposal has been under development by the USAF's Air Education and Training Command (AETC) since 2003. The upgrades currently being carried out on the in service T-38s are intended to keep the aircraft in service until at least 2020, by which time the new trainer programme will be ready to enter service. Problems with fatigue failures and a number of accidents in 2008 and 2009 caused the date to be moved forward to 2017 for a short time, but these have been the subject of a USAF comprehensive structural assessment which has confirmed the viability of the T-38 fleet until the original date.

Confirming this, the US Department of Defence 2013 budget requests have set the target for the initial operational capability for the T-X to Fiscal Year 2020. So far three company partnerships have responded with interest in the T-X programme, but discussions between these and other companies continue. At the moment, these are:

ALENIA AERMACCHI/ GENERAL DYNAMICS

The Alenia Aermacchi M-346 Master advanced jet trainer flew for the first time on July 15, 2004. The Italian, Republic of Singapore and Israeli air forces have all selected the type as their new advanced training platform. The M-346 is a transonic design powered by a pair of non-afterburning Honeywell F124-GA-200s of 6250lb (2850kg) thrust. Its transonic performance without afterburners is testimony to the aerodynamic efficiency of the airframe and significantly reduces operating costs. In order to fulfil the simulation and software elements of the T-X programme, Alenia Aermacchi signed a

Three prototypes of the Alenia Aermacchi M 346 Master advanced training aircraft. **Alenia Aermacchi**

The cockpit of the Alenia Aermacchi M 346 Master. **Alenia Aermacchi**

The BAE Systems Hawk T2 advanced trainer of the Royal Air Force. **BAE Systems**

letter of intent with General Dynamics C4 Systems in January 2013 to bid for the T-X contract. The M-346 has been redesignated as the T-100 Integrated Training System for the purposes of the competition and will be built in the United States if successful.

BAE SYSTEMS/L-3 LINK SIMULATION AND TRAINING/ NORTHROP GRUMMAN

The BAE Hawk is well known in the US, the aircraft being produced in partnership with Boeing, formerly McDonnell Douglas, as the T-45 Goshawk for the US Navy and Marine Corps. BAE Systems is proposing to offer an upgraded version of the Hawk T2/128 with a full glass cockpit, new wing and fuselage design, with Northrop Grumman as the manufacturing partner in the US. The simulator and software elements of the T-X package are to be provided by L-3 Link Simulation and Training, a division of L-3 Communications based in Arlington, Texas, which already supplies a wide variety of fixed and rotary wing simulators to the US military.

LOCKHEED MARTIN/KAI

The Korean Aerospace Industries T-50 Golden Eagle supersonic trainer was developed for the Korean Air Force requirement for a multi role training aircraft. The programme was developed in co-operation with Lockheed Martin from the beginning, with elements of the design experience from the F-16 Fighting Falcon being incorporated into the aircraft. The aircraft has already been developed into light attack and fighter variants and is in service with the Korean Air Force and, shortly, the Indonesian Air Force.

Several other nations are considering the type which is being jointly marketed by the two companies. Lockheed Martin believes the T-50 is uniquely qualified to meet the T-X requirement, as it was foreseen from the beginning of its development that the T-50 would make a suitable replacement for the T-38.

Lockheed Martin also built the F-22 and produces the F-35, the aircraft the T-X training programme is meant to prepare pilots for, and its Global Training and Logistics Division supplies military simulation and training systems and equipment.

Other than these partnerships, Boeing has also expressed an interest in the T-X programme, reportedly developing a brand new aircraft to meet the requirement, but is still in discussion with a number of other companies. Whichever is finally selected, the new trainer will need to be an extraordinary aircraft to replace the T-38 and match its track record as a reliable yet high performance aircraft. The abilities of the T-38 have made the aircraft a legend with many thousands of pilots, a legend that is set to continue for a number of years yet. ■ *Words: Tim Callaway*

The supersonic KAI T-50 is partnered by Lockheed Martin for the T-X competition. **Lockheed Martin**

The cockpit of the Hawk T2. **BAE Systems**

The cockpit of the KAI T-50 simulator. **Lockheed Martin**

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Survivors

Northrop F-5 and T-38 aircraft on display

The aerobatic teams featured earlier in this *Aviation Classics* are not the only way to still see a display by an F-5 or T-38, there are many air forces around the world still using the aircraft and a number have solo display aircraft that take part in air shows.

The clean lines of the Northrop fighter and trainer make it a beautiful aircraft to witness in flight – fast, lithe and surprisingly agile for an aircraft of its generation. The two afterburning General Electric J85 turbojets are remarkably quiet, giving a ghostly quality to the display, especially as its tiny head-on profile causes the aircraft to disappear occasionally. This means that pilots can surprise the crowd with sudden appearances, bringing an additional excitement to an F-5 display that is lacking in those of many of the more modern jet fighters. Despite their age, both the single and two seat versions of the aircraft acquit themselves superbly and are a popular addition to any display.

Although there are many F-5s and T-38s still in service, a large number of airframes have now become museum exhibits, particularly the early versions. The list of aircraft here is as complete as we can make it but, as ever, there may be aircraft we have missed or which have moved to new owners. As already mentioned, there are a surprisingly large number of preserved examples of the F-5/T-38 design, so if you know of any that are not listed here, please do let us know and we will publish the details on the Aviation Classics website. ■

61-0854/HM, a Northrop T-38A Talon on display in the Pima Air and Space Museum, Tucson, Arizona. **Constance Redgrave**

UNITED STATES OF AMERICA

ALABAMA

Birmingham – Southern Museum of Flight
62-3723 Northrop T-38A Talon

Huntsville – United States Space and Rocket Center
N580NA Northrop T-38A Talon

Maxwell AFB – Maxwell AFB Air Park
59-1601 Northrop T-38A Talon

ARIZONA

Mesa – The former Williams AFB 59-1600 Northrop T-38A

Tucson – Aerospace Maintenance and Regeneration Group (AMARG)
62-3653 Northrop T-38A Talon

Tucson – Pima Air and Space Museum
76-0441/FM Northrop F-5B Freedom Fighter
61-0854/HM Northrop T-38A Talon

Yuma – Yuma Marine Corps Air Station
Northrop F-5E Tiger II, Red 06, an aggressor aircraft of VMFT-401 Snipers

ARKANSAS

Eureka Springs – Aviation Cadet Museum
741528/05 Northrop F-5E Tiger II

CALIFORNIA

Atwater – Castle Air Museum
64-13271/BB Northrop T-38A Talon

Bakersfield – Kern County Museum 60-0566
60-0566 Northrop T-38A Talon
65-10441 Northrop T-38A Talon

Chino – Planes of Fame Air Museum
5243/61638 Northrop F-5E Tiger II

Chino – Yanks Air Museum
61-0908 Northrop T-38A Talon
76-1616 Northrop F-5E Tiger II in Taiwanese markings as it served with that nation's air force as 5221/5244

Compton – Tomorrow's Aeronautical Museum
61-0894 Northrop T-38A Talon

Los Angeles – California Science Center
58-1196 Northrop YT-38A Talon

Los Angeles – Flight Path Learning Center and Museum
N963NA Northrop T-38A Talon

March ARB (Riverside) – March Field Air Museum
60-0593/1 Northrop T-38A Talon

Merced – Castle AFB Museum, 52-1927 N-156T Northrop T-38 Talon

Palmdale – Joe Davies Heritage Airpark at Palmdale Plant 42
74-1529/06 Northrop F-5E Tiger II
63-8182/LB Northrop T-38A Talon

Paso Robles – Estrella Warbirds Museum
741537/08 Northrop F-5E Tiger II

San Diego – Flying Leatherneck Aviation Museum
74-1564/12 Northrop F-5E Tiger II

San Marino – Thornton Corporation
N675TC Northrop F-5B – airworthy
N685TC Northrop RF-5A – airworthy

Santa Rosa/Windsor – Pacific Coast Air Museum, 72-1387 F-5E Tiger II Northrop T-38 Talon

Torrance – Western Museum of Flight
207 Northrop F-5A Freedom Fighter

COLORADO

Colorado Springs – United States Air Force Academy
59-1602/1 Northrop T-38A Talon

FLORIDA

Merritt Island – Kennedy Space Center
N969NA/969 Northrop T-38N Talon

NAS Pensacola – National Museum of Naval Aviation
59-1604/15 Northrop T-38A Talon

Titusville – Valiant Air Command Warbirds Museum
74-1519 Northrop F-5E Tiger modified as the DARPA sonic boom test aircraft

GEORGIA

Warner Robins – Museum of Aviation
65-10325/ED Northrop T-38A Talon

ILLINOIS

Bloomington – Prairie Aviation Museum
60-0549/RA Northrop T-38A Talon

Rantoul – Octave Chanute Air Museum
63-8441 Northrop F-5B Freedom Fighter

KANSAS

Liberal – Mid America Air Museum
60-0583 Northrop GT-38A Talon

KENTUCKY

Lexington – Aviation Museum of Kentucky
64-13292 Northrop AT-38B Talon

MINNESOTA

Anoka County – Blaine Airport (Janes Field)
74-1539 Northrop F-5E Tiger II

Owatonna – Degner Regional Airport
60-0573 Northrop AT-38B Talon
60-0589 Northrop AT-38B Talon
61-0828 Northrop AT-38B **Talon** – both this and the

N586PC, a civilian owned airworthy Northrop F-5B belonging to the F-5 Corporation of Seattle, Washington. **Keith Draycott**

76-0441/FM, a Northrop F-5B Freedom Fighter on display in the Pima Air and Space Museum, Tucson, Arizona. **Constance Redgrave**

74-1564/12, a Northrop F-5E Tiger II in the markings of VMFT-401, the Snipers, on display in the Flying Leatherneck Aviation Museum at Miramar, near San Diego, California. **Constance Redgrave**

previous two aircraft are in Thunderbirds markings

NEBRASKA

Spalding – ALP 299 Memorial
60-0567 Northrop GT-38A Talon

NEVADA

Nellis AFB – Freedom Park
74-1571/WA-65 Northrop F-5E Tiger II

NEW JERSEY

Cape May County Airport – NAS Wildwood Aviation Museum
74-1572 Northrop F-5E Tiger II

NEW MEXICO

Gallup Municipal Airport
61-0829 Northrop T-38A Talon
Santa Teresa – War Eagles Air Museum
64-13267 Northrop AT-38B Talon

NEW YORK

Bruston-Moira – American Legion Post 939
61-0806 Northrop AT-38B Talon

NORTH CAROLINA

Hickory – Hickory Aviation Museum
141540 Northrop F-5E Tiger

OHIO

Dayton - USAF Museum Wright Patterson AFB
59-4989 Northrop YF-5A Freedom Fighter
60-0566 Northrop T-38A Talon
63-8172 Northrop AT-38A Talon
65-10441 Northrop T-38A Talon

OKLAHOMA

Tinker AFB - Charles B Hall Airpark
61-0817/HM Northrop GAT-38B Talon
Tulsa - United States Aviation Museum Inc
N8910 Canadair built Northrop NF-5B - Airworthy
Weatherford - Stafford Air & Space Center
T-38 Talon

OREGON

McMinnville - Evergreen Aviation and Space Museum
74-1556/56 Northrop F-5E Tiger II
63-8224/68 Northrop T-38A Talon
Hillsboro – Classic Aircraft Museum,
Northrop F-5E Tiger II
Northrop F-5F

SOUTH DAKOTA

Ellsworth AFB – South Dakota Air and Space Museum
58-1192 Northrop YT-38A Talon

TEXAS

Big Spring – Hangar 25 Air Museum
64-13198 Northrop T-38A Talon
Burnet Municipal Airport – Kate Craddock Field
60-0594 Northop AT-38A Talon
Dallas – Frontiers of Flight Museum
62-3645 Northrop T-38A Talon
Dyess AFB – Linear Air Park
60-0592 Northrop GT-38A Talon
Mineral Wells Airport
61-0809 Northrop AT-38B Talon

UTAH

Hill AFB – Hill Aerospace Museum
73-1640/40 Northrop F-5E Tiger II
61-0824 Northrop T-38A Talon
Southern Utah Air Museum
64-13179 Northrop T-38A Talon

WASHINGTON

Seattle-Boeing Field – The Museum of Flight
59-4987/F-987 Northrop YF-5A Freedom Fighter
Seattle – The F-5 Corporation
N586PC Northrop F-5B – airworthy

CANADA

Ontario
CFB Borden – Base Borden Military Museum
CF-116 (Canadian version of F-5 Freedom Fighter)

NOVA SCOTIA

Shearwater – Shearwater Aviation Museum
116832 Northrop CF-116B (F-5B) Freedom Fighter

SOUTH AMERICA

Chile Los Cerrillos Santiago de Chile – Museo Aeronáutico y del Espacio
811 Northrop F-5E Tiger II
812 Northrop F-5E Tiger II
813 Northrop F-5E Tiger II

BRAZIL

Rio de Janeiro – Campo Dos Afonsos Museu Aeroespacial
4800 Northrop F-5B

EUROPE

Greece
Aghialos National Airport
69228 Northrop F-5A Freedom Fighter
Athens – War Museum
689071 Northrop F-5 Freedom Fighter
Dekeleia – Tatoi AB – Hellenic Air Force Museum
65-10541 Northrop F-5A Freedom Fighter
69-7170 Northrop RF-5A Freedom Fighter
51-17011 Northrop RF-5A Freedom Fighter
Lamia – Central Town Park
10577 Northrop F-5A Freedom Fighter
Larisa – Larisa Base Museum
51-11294 Northrop F-5A
52-8728 Freedom Fighter
Tanagra – Tanagra Base Collection
6662/ FG-6662 Northrop F-5A Freedom Fighter
Thessaloniki – Thessaloniki War Museum
13353 Northrop F-5A Freedom Fighter

NETHERLANDS

Soesterberg – Militaire Luchtvaart Museum
K-4011 Northrop NF-5B Freedom Fighter
K-30-29 Northrop NF-5A

NORWAY

Bodoe – Norsk Luftfartsmuseum
563 Northrop F-5A Freedom Fighter
Stavanger – Sola Airport – Flyhistorisk Museum Sola
14896/DP-C Northrop F-5A Freedom Fighter

POLAND

Krakow – Muzeum Lotnictwa Polskiego
73-00852 Northrop F-5E Tiger II

PORTUGAL

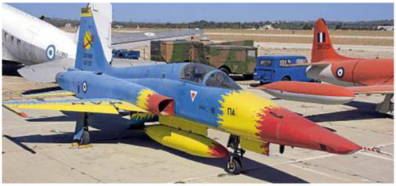
Alverca – Museu do Ar
2601 Northrop T-38A Talon
Sintra – Museu do Ar
2605 Northrop T-38A Talon

SLOVAKIA

Kosice – Muzeum Letectva
65-10456 Northrop AT-38B Talon
7 Northrop NF-5A Freedom Fighter

59-4987/F-987, a rare Northrop YF-5A Freedom Fighter on display in the Museum of Flight at Boeing Field in Seattle, Washington. **Editor**

69-228, a Northrop F-5A Freedom Fighter of the Hellenic Air Force, now on display at Aghialos National Airport, Greece. **Chris Lofting**



69-7170, a brightly marked Northrop RF-5A Freedom Fighter of the Hellenic Air Force now on display in the Hellenic Air Force Museum at Dekeleia – Tatoi Air Base. **Chris Lofting**

59-1604/15, a Northrop T-38A Talon in the markings of the US Naval Test Pilots School, on display at the stunning National Museum of Naval Aviation at NAS Pensacola, Florida. **Constance Redgrave**

SPAIN

Madrid – Cuatro Vientos Air Base – Museo del Aire
AR9-062/23-62 Casa-Northrop RF-5A
A9-050/23-62 Casa-Northrop SF-5A
A9-05/23-29 Casa-Northrop F-5A in storage

SWITZERLAND

Dubendorf – Flieger Flab Museum
J-3013 Northrop F-5E Tiger

TURKEY

Ankara – ODTÜ Bilim ve Teknoloji Müzesi
64-13349 Northrop F-5A Freedom Fighter
Ankara – Hava Kuvvetleri Muzesi Komutanligi Turkish Air Force Museum
10575/5-575 Northrop F-5A Freedom Fighter
14465/3-465 Northrop F-5A Freedom Fighter
4014 Northrop NF-5B Freedom Fighter
21208/3-208 Northrop RF-5A Freedom Fighter
Eskisehir – Eskisehir Havacilik Parki ve Tayyare Muzesi
61-3346/3-346 Northrop F-5A Freedom Fighter
66-9212/5-212 Northrop F-5A Freedom Fighter
Istanbul – Yesilkoy Hava Kuvvetleri Muzesi Komutanligi Turkish Air Force Museum
14460 Northrop F-5A Freedom Fighter
3022/22 Northrop NF-5A Freedom Fighter
3070/3-070 Northrop NF-5A Freedom Fighter
97147/5-147 Northrop RF-5A Freedom Fighter

ASIA

China
Xiaotangshan – China Aviation Museum – Northrop F-5A Freedom Fighter
5361 Northrop F-5F Tiger II

MALAYSIA

Kuala Lumpur – Sungai Besi Air Force Base
M29-12 Northrop F-5E Tiger II

PHILIPPINES

Clark AB – Air Force City Park
10507 Northrop F-5A Freedom Fighter
Villamor AB (Manila IAP) – Philippine Air Force Museum
13326 Northrop F-5A Freedom Fighter

REPUBLIC OF KOREA

Daejeon – Daejeon National Cemetery
20-442 Northrop F-5B Freedom Fighter
Sacheon – KAI Aerospace Museum
10-552 Northrop F-5A Freedom Fighter
Seongmu – Republic of Korea Air Force Museum
10-529 Northrop F-5A Freedom Fighter
68-095 Northrop F-5B Freedom Fighter
Seoul – Boramae Park
42-117 Northrop F-5B Freedom Fighter
Seoul – War Memorial Museum
89-046 Northrop F-5A Freedom fighter

SINGAPORE

Paya Lebar Air Base.
A Maverick-armed F-5S Tiger II of Republic of Singapore Air Force on static display

REPUBLIC OF CHINA (TAIWAN)

Several retired F-5E/Fs are used as decoys deployed around major air bases
The prototype of AIDC's Tiger 2000/2001, an upgrade program for the F-5E and F with a new radar, is on display in AIDC in Central Taiwan

THAILAND

Thanon Kan Ta Rat / Thanon Phahonyothin
Northrop F-5 on display – details unknown

Bangkok – Don Muang Airport – Royal Thai Air Force Museum
67-21167 Northrop F-5A Freedom Fighter
69-7101 Northrop F-5A Freedom Fighter
69-7110 Northrop F-5A Freedom Fighter
71-0276 Northrop F-5A Freedom Fighter
69159/1311 Northrop F-5A Freedom Fighter
BKh18-13/17/70143/38371 Northrop F-5A Freedom Fighter
Kh18k-1/09/70101/38438 Northrop F-5B Freedom Fighter
TKh18-3/13/70104/97158 Northrop RF-5A Freedom Fighter

VIETNAM

Hanoi – Bao Tang Phong Khong – Khong Quan (Air Force Museum)
7579 Northrop F-5A Freedom Fighter
Ho Chi Minh City – Ho Chi Minh Museum
10272 Northrop F-5A Freedom Fighter
Ho Chi Minh City – Ho Chi Minh City Museum
10271 Northrop F-5A Freedom Fighter
Ho Chi Minh City – Reunification Palace (Hoi Truong Thong Nhat)
01638 Northrop F-5E Tiger
Ho Chi Minh City – Tan Son Nhut Air Force Museum
7579 Northrop F-5A Freedom Fighter
Ho Chi Minh City – War Remnants Museum (Nha Trung Bay Toi Ac Chien Tranh)
9170 Northrop F-5A Freedom Fighter

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100 years of Alenia Aermacchi

The prototype of the Alenia Aermacchi M-346 transonic military training aircraft, one of the current range of types produced by the Italian aerospace giant. **Alenia Aermacchi**

The next issue of *Aviation Classics* traces the complete history of one of the most successful aviation companies in Europe in this, its centenary year. In 1912, Guilio Macchi founded Aeronautica Macchi on the shores of Lake Varese in Lombardy. The new company was to produce some of the most unusual fighter aircraft of the First World War as the majority of these were fighter flying boats. During the interwar years, the name of Macchi became synonymous with high speed racing seaplanes, becoming world famous through its participation in the Schnieder Trophy. Other types of aircraft from airliners to trainers were also produced during this period, as well as the first of a family of fighter designs that were to remain in production throughout the Second World War. Postwar, the company began to produce a range of motorcycles, particularly racing machines, while the world market for aircraft re-established itself. From the 1950s onwards, Aermacchi introduced the first of a range of military jet trainers that continues to this day, bringing global success to the company as these were sold to air forces all over the world. Various amalgamations with other aeronautical companies throughout the 1990s resulted in the formation of Alenia Aermacchi in 2012 as part of the Finmeccanica Group. The company is a major partner in many international military aircraft programmes, such as the AMX, Panavia Tornado, Eurofighter Typhoon and F-35 Lightning II, as well as the ATR 42 and 72, Boeing 787 and Airbus family of airliners. Alenia Aermacchi also produces the remarkably agile C-27J Spartan military transport and a range of unmanned aerial vehicles, as well as continuing to produce world class military trainers such as the M-346 pictured here. *Aviation Classics* celebrates the history of this remarkable company throughout its 100 years, covering all of the major developments and designs that form a story of innovation and genius at the cutting edge of aerospace development.

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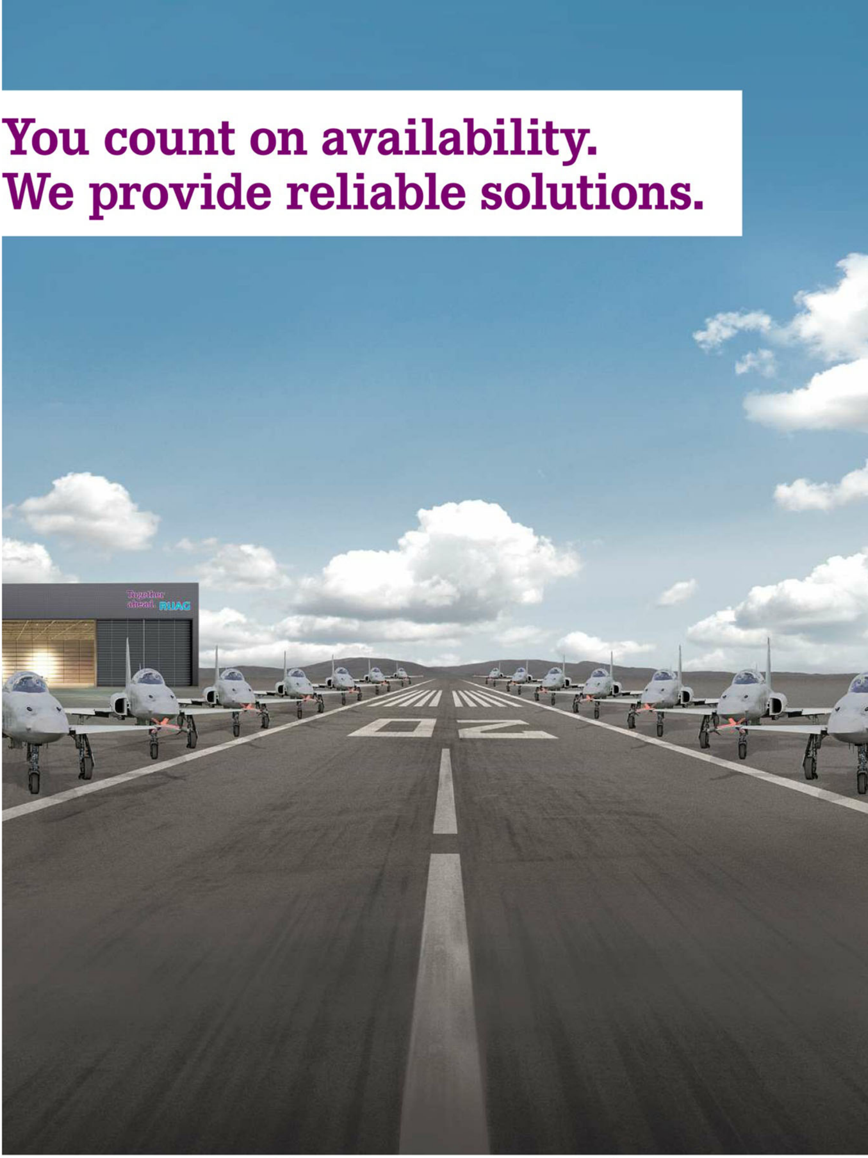

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6032 Emmen | Switzerland | Phone +41 41 268 41 11
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